SECTION 5.0

Electric Transmission

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5.1 Introduction

Section 5 discusses the transmission interconnection between the Central Valley Energy Center (CVEC) and the existing electrical grid, and the anticipated impacts that operation of the facility will have on the flow of electrical power in the central region of California. To better understand the impacts of the proposed energy center on the regional transmission and power flows, the discussions in this section will focus on those areas that allow a critical review of the electrical transmission and interconnection. More specifically, this analysis will contain discussions on:

- The existing electrical transmission system in the immediate area of CVEC
- The proposed electrical interconnection between CVEC and the electrical grid
- The proposed electrical transmission line alignment
- The impacts of the electrical interconnection on the existing transmission grid
- Alternatives to the proposed interconnection and line alignment
- Potential nuisances (electrical, magnetic, audible noise, and corona effects)
- Safety of the interconnection
- Description of applicable laws, ordinances, regulations, and standards (LORS)

The proposed CVEC site is located in an industrial area of the City of San Joaquin, California in central Fresno County. This location was selected, in part, for its proximity to: (1) the anticipated load; (2) reliable high voltage transmission lines; and (3) a substation. (The Pacific Gas & Electric Company's (PG&E) Helm Substation is approximately 1,500 feet to the south of the CVEC site). Figure 5.1-1 (all figures are located at the end of the section) shows the location of CVEC in relationship to the Helm Substation and the existing 230-kV transmission lines. Figure 5.1-1 also demonstrates that both the CVEC site and the existing Helm Substation are in close proximity to two existing 230-kV transmission circuits: Panoche-Kearney (with McMullin substation tapped off) and Panoche-McCall (accesses the Helm Substation). This physical proximity (1,200 feet south of the CVEC site and 300 feet north of the Helm Substation) will allow for a short interconnecting transmission line between the two facilities.

PG&E owns and maintains the two high-voltage transmission lines in the vicinity of CVEC, with the California Independent System Operator (CAISO) having the operational control over these transmission facilities. These lines are a part of PG&E's San Joaquin Valley Operating Region (San Joaquin Division). This existing transmission network will deliver the power generated at CVEC to the California electric transmission grid. Figure 5.1-1 illustrates the existing high-voltage transmission system in the immediate vicinity of the CVEC project.

The initial examination of the local transmission system concentrated on the anticipated CVEC power flows, capacity and location of existing transmission lines, availability of substation capacity, and physical distances involved with the anticipated electrical interconnection. The interconnection feasibility study included an analysis of several different electrical configurations including radially connecting CVEC to the existing transmission system at the Helm Substation and looping the existing 230-kV electrical transmission lines into the proposed CVEC switchyard. As a result of the nominal 1060-MW net capacity of CVEC and the proximity of existing 230-kV lines, system analyses concentrated on looping one or both these lines into the switchyard.

As proposed, electrical transmission interconnection will connect CVEC to the regional power grid by looping the nearby Panoche-McCall (Helm) and the Panoche-Kearney (with McMullin tap) 230-kV transmission lines into the CVEC switchyard (Figure 5.1-1). The physical components of the interconnection will involve 2 double-circuit 230-kV lines approximately 1,300 and 1,500 feet long looping the CVEC switchyard into the 230-kV lines near the Helm Substation. The proposed connection will align in a north/south direction and cross open farmland. Figure 5.1-2 illustrates alignment of the proposed interconnection in relationship to the proposed CVEC site, the nearby double-circuit 230-kV transmission line, and the existing Helm Substation. In Figure 5.1-2, these features are superimposed on an aerial photograph of the area in the immediate vicinity of the CVEC (south of the City of San Joaquin). This allows the reader to compare the proposed components (plant site, connection corridor, and Helm Substation) with geographic features, agricultural fields, and recent development of this part of Fresno County.

The proximity of the 230-kV transmission lines to the CVEC project conceptually allows for a relatively short interconnection to be considered with respect to its feasibility, anticipated impact on the existing transmission system, and projected power flows. Primary consideration in the analysis was given to the ability of the existing transmission lines to carry the anticipated output of CVEC. Additional aspects considered included environmental effects of building and maintaining the new interconnecting transmission line, right-of-way modification and/or acquisition, and engineering constraints. Alternative interconnection options were identified after analyses of these data and review of the PG&E operating diagram for this operating region of their service area. From these alternatives, the proposed transmission line alignment, interconnection configuration, and construction techniques were selected. Figures 5.1-3a and 5.1-3b (attached in separate map pockets at the end of this section) are the Operating Diagrams for PG&E's San Joaquin operating region (San Joaquin Division-Sheets 3 and 4). Further analysis based on the Interconnection Data Sheet (attached as Appendix 5A) and discussion of the proposed interconnection, its alignment, and alternatives are found below in Sections 5.2 and 5.3.

5.2 Transmission Interconnection Engineering

Preliminary engineering of the proposed transmission interconnection was completed as a result of the above activities. This section discusses the existing transmission facilities in the vicinity of the CVEC project and the conceptual design of the interconnection transmission line and CVEC switchyard.

5.2.1 Existing Electrical Transmission Facilities

The proposed CVEC site is approximately 85 acres in size and is located approximately 1,500 feet north of PG&E's Helm Substation in central Fresno County, California. An inventory and assessment of the transmission facilities in the immediate geographic area of the CVEC project was conducted. The regional transmission line assessment focused on the number of electrical transmission lines, the rating of each line, the existing loads, and the ability of the existing transmission grid to safely and reliably transport the anticipated base load of 821 MW of power to be generated at CVEC.

Based on the study plan base case provided by PG&E, which is based on the 2001-series transmission assessment summer peak load case for 2003, the portion of PG&E's service area that CVEC might readily impact[1] has approximately 2850 MW of peak load and 1800 MW of existing generation.[2] Presently, the transmission system in the vicinity of Helm substation consists of two 230-kV transmission lines and four 70-kV subtransmission lines. The circuit on the north side of the 230-kV

1 PG&E Fresno (zones 314 and 344) and Yosemite (zones 313 and 343) zones used to approximate this area.
2 This represents the total generation modeled as running in the power flow case.

towers, designated Panoche-McCall, enters the Helm substation by dipping under the south circuit immediately north of the substation at tower 24/122A (shown in Figures 5.1-1 and 5.1-2). The south circuit does not enter the Helm Substation and extends from Panoche to Kearney Substation with McMullin Substation tapped off of this 230-kV line. The transmission lines and their relationship to CVEC and the Helm Substation are shown geographically in Figures 5.1-1 and 5.1-2. Local 230-kV ratings are typically 295 to 328 million volt ampere (MVA). Local 70-kV ratings are typically 39 to 77 MVA. Table 5.2-1 lists the ratings and conductor types for selected lines.

TABLE 5.2-1
Capabilities of Lines in the Vicinity of the Helm Substation

From	To	Ckt. No.	Description	Volt (kV)	Normal Rate (MVA)	Emerg Rate (MVA)	Conductor
Panoche	McMullin[3]	1	One circuit of a double-circuit	230	328	388	1113 Al
Panoche	Helm	1	One circuit of a double-circuit	230	295	338	795 ACSR
Helm	McCall	1	One circuit of a double-circuit	230	295	338	795 ACSR
Helm	Helm	1	230/70-kV Transformer	230/70	134	161	
Helm	Stroud	1	Single-circuit	70	39	45	3/0 Cu
Helm	Valley Nitrogen	1	Single-circuit	70	76	89	715.5 Al
Helm	San Joaquin	1	Single-circuit	70	39	46	3/0 Cu
Helm	San Joaquin Jct	1	Single-circuit	70	77	90	266.8 Al

To evaluate the transmission capability near the Helm Substation, an approach called the “first contingency rated exit capability,” or FCREC, was used. The evaluation started with the study plan case provided by PG&E. This information was supplemented with connection information and line ratings from the San Joaquin Operating Region (San Joaquin Division, Sheets 3 and 4) Operating Diagram (Figures 5.1-3a and b), taken from PG&E’s Form 715 filing previously submitted to the Federal Energy Regulatory Commission (FERC). From this database, an inventory of substation buses, generation, load, and line capacity was developed for the transmission system near the Helm Substation. This inventory, starting with the substation itself, served as a starting point for the FCREC method of evaluation. The objective of the evaluation was to find the rated exit capability for the area near the Helm Substation. To find the rated capability, the following steps were undertaken:

1. Add the rating of all lines leaving, or exiting, the group
2. Subtract the rating of all generators attached to any bus within the group
3. Add the rating of all loads attached to any bus within the group

The sum of Steps 1, 2, and 3, above, yields a number called the “normal total rated exit capability,” or NTREC, for the group. (The group of buses may also be called a “cut set.”) The NTREC represents the maximum possible additional generation that can be accommodated at the cut-set location under the best of conditions. This is an optimistic number, but it can be refined easily using standard power-flow methodology.

3 If this circuit is looped into the CVEC Substation, the result is two lines each rated at 328 MVA.

The FCREC is a refined estimate of capacity. This number takes into account the most severe single contingency, or line outage. It provides a more realistic limit for added generation than does the NTREC found as a result of Steps 1, 2, and 3 above. To calculate the FCREC, or the final estimate of system capability, step 4 is added to the process:

4. Subtract the rating of the line exiting the cut set that has the highest rating.

The FCREC gives the maximum possible export that might be expected without necessitating system improvements. Detailed estimates of the system impact will be determined in a System Impact Study sponsored by the Applicant and conducted by PG&E in accordance with the study plan developed for CVEC. Appendix 5B (5 CD-ROM copies have been provided to the CEC) contains the study plan for the proposed System Impact Study.

Since there is no load and no generation at the Helm Substation, the NTREC for the substation is 1,380 MVA.[4] The FCREC is 1,052 MVA, which is the maximum amount of generation that one might expect to add near the Helm Substation without necessitating system improvements. Based on this abbreviated analysis, the addition of new generation near the Helm Substation will result in minimal transmission impacts. A more accurate estimate of system impacts is presented in the section on system impacts that follows.

5.2.2 Proposed Transmission Interconnection System

The interconnection between the proposed CVEC and the Helm Substation will consist of the following major facilities:

- Two new double-circuit overhead lines extending approximately 1,300 and 1,500 feet to loop the Panoche-McCall and Panoche-Kearney 230-kV transmission lines into the CVEC switchyard (Figures 5.1-1 and 5.1-2)
- New 230-kV switchyard using a 12-position breaker and half configuration adjacent (southeast side) to the CVEC power block

As a result of the CVEC’s physical orientation on the proposed site, the transmission interconnection will exit the switchyard at the pull-off structure in a southeast direction. At Springfield Avenue the four circuits will turn approximately 45º and proceed due south a little over 1,200 feet to where it will intersect with the existing Panoche-McCall (Helm) and Panoche-Kearney 230-kV transmission lines. At that point, the two existing lines will be uncrossed as they are looped into the CVEC switchyard. This will create four new lines. The existing Panoche-McCall (Helm) will be designated Panoche-CVEC, CVEC-McCall, and the existing Panoche-Kearney will become the Panoche-Helm, and CVEC-Kearney (with McMullin Substation tapped of this line). In addition, a new 230-kV circuit will be built between CVEC and the Helm Substation to complete the interconnecting loop. Figures 5.1-1 and 5.1-2 illustrate the transmission designations after the construction of the CVEC and the interconnection. It is anticipated that the interconnecting transmission will occupy a right-of-way approximately 100 feet in width.

The construction of CVEC will necessitate the re-routing of the 70-kV Helm-Kerman, single-circuit, transmission line. Presently, it extends north across Springfield Road at the intersection of Placer Avenue (which it parallels). This effectively bisects the proposed CVEC site (Figures 5.1-1 and 5.1-2). The line will be re-routed as illustrated in Figures 5.1-1 and 5.1-2 to more align it with the property boundaries of CVEC.

4 Summation of all 230- and 70-kV lines exiting Helm results in an NTREC of 1,477 MVA. However, since the amount of power that can be transferred to the 70-kV lines is limited by the 134 MVA rating of the Helm 230/70-kV transformer, the NTREC is the total capability of the four 230-kV lines and the 230/70-kV transformer, 1,380 MVA. The FCREC is then 1,380 MVA – 328 MVA = 1,052 MVA.

5.2.2.1 Central Valley Energy Center 230-kV Switchyard Characteristics

The proposed CVEC 230-kV switchyard will consist of twelve, 230-kV air-insulated circuit breakers. A breaker-and-a-half bus arrangement will be used in the switchyard to obtain a high level of service reliability. An electrical one-line diagram of the proposed CVEC switchyard arrangement appears in Figure 5.2-1. The switchyard layout is shown in Figure 5.2-2.

The switchyard and all equipment will be designed for a 63 kA interrupting capacity. The main buses, as well as the bays, will be designed for 3,000 A continuous current. As depicted in Figure 5.2-1, each generator will be provided with an independent tie to the switchyard. The CVEC switchyard will be connected by looping the nearby Panoche-McCall (Helm) and Panoche-Kearney 230-kV transmission lines into the CVEC switchyard. The looping configuration of the interconnection will not require any major modifications of the Helm Substation. Four line exits allow removal of a single-circuit without limiting plant output under most system conditions. Redundant 18/13.8-kV Unit Auxiliary Transformers connected between CTG generator breakers two and three and the respective step-up transformers will provide power to start up the plant and provide power for all auxiliary loads within the CVEC facility. Auxiliary controls and protective relay systems for the 230-kV switchyard will be located in a control building separate from the power plant.

5.2.2.2 Overhead Line Characteristics

Power generated at CVEC will be delivered to the California transmission grid through a looped interconnection. The existing Panoche-Helm-McCall (Helm) 230-kV and the Panoche-Kearney 230-kV lines will both be looped into the CVEC switchyard (Figures 5.1-1 and 5.1-2). This configuration will also allow for the uncrossing of the Panoche-Helm-McCall line from its present configuration where it enters the Helm Substation.

The looping of these two lines into the CVEC switchyard will necessitate the design and construction of two new double-circuit 230-kV transmission lines approximately 1,500 feet long between the switchyard and the Helm Substation. The proposed conductor for the two new circuits is 954A kcmil, 45/7 ACSS "Rail."

The proposed interconnecting lines will exit the CVEC switchyard in a southeast direction for approximately 350 feet to the north side of West Springfield Avenue. The proposed line will turn approximately 55° as it crosses West Springfield Avenue and heads directly south for approximately 1,300 additional feet where it will intercept the two existing PG&E 230-kV lines. At this intersection point, one of the new western circuits will enter the Helm Substation and be designated the CVEC-Helm 230-kV line. The other western circuit will connect to the Panoche-Helm 230-kV line and be redesignated the Panoche-CVEC 230-kV line. The two eastern circuits will connect to the existing Helm-McCall and the eastern portion of the Panoche-Kearney lines. These lines will be re-designated the CVEC-McCall and the CVEC-Kearney (with McMullin Substation tap) 230-kV lines respectively. The proposed line redesignating and the two new 230-kV lines are illustrated in Figure 5.1-2.

The proposed interconnecting transmission line will be built as two adjacent double-circuit lines, sharing the same 100-foot wide right-of-way, between the CVEC switchyard and the Helm Substation. The lines will exit the CVEC switchyard as a slack span to a terminal dead-end structure located southeast of the switchyard. Figure 5.2-4 illustrates the concept of the dead-end structure. One such structure will support each circuit (total of four) as they exit the switchyard. The dead-end structure will be approximately 105 feet tall. The location of these structures in relation to the other major components of the project can be seen in Figure 5.2-3. They will be located in the area labeled "Figure 5.2-4."

The lines then span southeast approximately 300 feet and 375 feet to two new double-circuit heavy angle non-terminal dead-end structures immediately north of West Springfield Avenue. Figure 5.2-5 illustrates the concept of the non-terminal dead-end structure. The location of these structures is illustrated in Figure 5.2-3 at the point labeled “Figure 5.2-5.” The structure will be approximately 110 feet tall. At these structures, the line alignment will angle from southeast to due south.

The lines are then routed south across West Springfield Avenue for approximately 650 feet to 2 double-circuit tangent structures, which will be approximately 110 feet tall. Figure 5.2-6 illustrates the concept of the tangent structure. The location of these structures is illustrated in Figure 5.2-3 at the point labeled “Figure 5.2-6.”

The lines continue to travel south approximately 625 feet where they intercept the two existing 230-kV lines. The westerly double-circuit lines dead-end on a 3-way dead-end structure. One of the two circuits turns west 90°, connects to the existing Panoche-Helm line and continues west. The other circuit angles to the south-southeast into the Helm Substation, a distance of approximately 290 feet. The third position on the 3-way dead-end structure supports the Panoche-Helm line where it turns south into the substation. Figure 5.2-7 illustrates the concept of the 3-way dead-end structure. The structure will be approximately 110 feet tall. The location of this structure is illustrated in Figure 5.2-3 at the point labeled “Figure 5.2-7.”

The easterly double-circuit lines terminate on two terminal dead-end structures. Here they turn east 90° and connect to the existing Helm-McCall and Panoche-Kearney 230-kV lines heading east. Figure 5.2-8 illustrates the concept of the terminal dead-end structures. These structures will also be approximately 110 feet tall. The location of these structures is illustrated in Figure 5.2-3 at a point labeled “Figure 5.2-8.”

The two circuits entering the Helm Substation will be supported by the 3-way dead-end structure discussed above. From this structure, the two circuits will be connected to the low-tension pull-off structures inside the Helm Substation as slack spans (Figure 5.2-3).

5.3 Proposed Transmission Interconnection Alternatives

This section describes alternatives to the proposed electrical transmission interconnection discussed in Section 5.2. One of the results of the transmission resource analysis was the development of several additional conceptual transmission interconnection options. Factors considered in the development and selection of the proposed transmission interconnection were: a) the ability of the existing transmission resources to carry the power generated by the CVEC, b) environmental consequences, c) ability to secure any additional rights-of-way (if needed), and d) engineering considerations and constraints. Due to its remoteness, this location had only one viable existing transmission alignment for the interconnection. This is discussed above in Section 5.2. However, several substation system alternatives were investigated. They are discussed below. Other alternatives, not discussed below, were delineated, assessed, and rejected as clearly inferior.

5.3.1 Alternative 1 – Loop into a Single 230-kV Circuit

This alternative transmission interconnection consists of the following major elements:

- New double-circuit overhead lines extending approximately 1,500 feet to loop either the Panoche-McCall or the Panoche-Kearney 230-kV transmission line into the CVEC switchyard.
- New 230-kV switchyard using a 12-position breaker and half ring-bus configuration adjacent (southeast side) to the CVEC power block

This alternative is inadequate because two 230-kV circuits of the type available at the site are insufficient to carry the plant output.

5.3.2 Alternative 2 – Radial Connection to Modified Helm Substation

This alternative transmission interconnection consists of the following major elements:

- New double-circuit overhead lines extending approximately 1,500 feet to loop either the Panoche-McCall or the Panoche-Kearney 230-kV transmission line into the CVEC switchyard.
- New 230-kV switchyard using a 12-position breaker and half ring-bus configuration adjacent (southeast side) to the CVEC power block
- Expansion of the Helm Substation by adding a 9-breaker, breaker and one half extension.

This alternative creates a second new substation that provided for a radial connection of the CVEC grid to the PG&E transmission system. It also reduces the circuits crossing the road to the CVEC switchyard. This configuration was rejected because of its increased cost and potential environmental impacts.

5.4 Interconnection System Impact Study

Interconnection studies include analysis of power flow, short circuit, transient stability, and other factors to assess the impacts of the proposed transmission interconnection on the integrated transmission grid. After contacting PG&E and following mutually agreed upon procedures between the Applicant and PG&E and in accordance with PG&E's regulatory filings, PG&E conducted the System Impact Study that was initiated by the Applicant. A copy of this study plan is included as Appendix 5B. The Interconnection Data Sheet submitted by the Applicant is included in Appendix 5A. These documents are included for information and to record the chronological development, to the time of submission of this application, of the system impact studies. PG&E's system impact study will be submitted under separate cover.

Prior to selecting the CVEC site, the Applicant performed several studies to verify its suitability for development as a potential generation location. Based on the results of these studies, the Applicant believes that there will be minimal transmission impacts. The Applicant is diligently working with PG&E and CAISO to develop solutions (including but not limited to, rerating the existing transmission facilities for higher capacity based on 4 feet per second wind speed, feasibility of development to operating procedures, switching solutions, and installation of Remedial Action Schemes) to address all possible impacts of the CVEC on the local area transmission system.

5.5 Transmission Line Safety and Nuisance

This section discusses safety and nuisance issues associated with the proposed electrical interconnection of the CVEC with the electrical grid. Construction and operation of the proposed overhead transmission line will be undertaken in a manner to ensure the safety of the public as well as maintenance and right-of-way crews while supplying power with minimal electrical interference.

5.5.1 Electrical Clearances

Typical high-voltage overhead transmission lines are composed of bare conductors connected to supporting structures by means of porcelain, glass, or plastic insulators. The air surrounding the energized conductor acts as the insulating medium. Maintaining sufficient clearances, or air space, around the conductors to protect the public and utility workers is paramount to ensure safe operation of the line. The safety clearance required around the conductors is determined by: normal operating voltages, conductor temperatures, short-term abnormal voltages, wind-blown swinging conductors, contamination of the insulators, clearances for workers, and clearances for public safety. Minimum clearances are specified in the National Electric Safety Code (NESC). Electric utilities, state regulators, and local ordinances may specify additional (more restrictive) clearances. Typically, clearances are specified for:

- Distance between the energized conductors themselves
- Distance between the energized conductors and the supporting structure
- Distance between the energized conductors and other power or communication wires on the same supporting structure, or between other power or communication wires above or below the conductors
- Distance from the energized conductors to the ground and features such as roadways, railroads, driveways, parking lots, navigable waterways, airports, etc.
- Distance from the energized conductors to buildings and signs
- Distance from the energized conductors to other parallel power lines

The proposed CVEC transmission interconnection will be designed to meet all national, state, and local code clearance requirements. Since the designer must take into consideration many different situations, the generalized dimensions provided in the figures of this section should be regarded as reference for the electric and magnetic field calculations only and not absolute. The minimum ground clearance for 70-kV transmission (per the NESC) is 19.2 feet, based on the road-crossing minimum. The minimum ground clearance for 230-kV transmission (per the NESC) is 22.4 feet, based on the road-crossing minimum. These are the design clearances for the maximum operating temperature of the line. Under normal conditions, the line operates well below maximum conductor temperature, and thus, the average clearance is much greater than the minimum. The electrical effects calculations are based on a 30-foot clearance for both the 70-kV and 230-kV lines per PG&E guidelines. The final design value will be consistent with General Order 95 (GO-95) of the California Public Utilities Commission and PG&E's guidelines for electric and magnetic field (EMF) reduction.

5.5.2 Electrical Effects

The electrical effects of high-voltage transmission lines fall into two broad categories: corona effects and field effects. Corona is the ionization of the air that occurs at the surface of the energized conductor and suspension hardware due to very high electric field strength at the surface of the metal during certain conditions. Corona may result in radio and television reception interference, audible noise, light, and production of ozone. This study includes audible noise considerations only. Field effects are the voltages and currents that may be induced in nearby conducting objects. The transmission line's 60 hertz (Hz) electric and magnetic fields cause these effects.

5.5.2.1 Electric and Magnetic Fields

Operating power lines, like the energized components of electrical motors, home wiring, lighting, and all other electrical appliances, produce electric and magnetic fields, commonly referred to as EMF. The EMF produced by the alternating current electrical power system in the United States has a frequency of 60 Hz, meaning that the intensity and orientation of the field changes 60 times per second.

The 60 Hz power line fields are considered to be extremely low frequency. Other common frequencies are AM radio, which operates up to 1,600,000 Hz (1,600 kHz); television, 890,000,000 Hz (890 MHz); cellular telephones, 900,000,000 Hz (900 MHz); microwave ovens, 2,450,000,000 Hz (2.4 GHz); and X-rays, about 1 billion billion (10^{18}) hertz. Higher frequency fields have shorter wavelengths and greater energy in the field. Microwave wavelengths are a few inches long and have enough energy to cause heating in conducting objects. High frequencies, such as X-rays, have enough energy to cause ionization (breaking of molecular bonds). At the 60 Hz frequency associated with electric power transmission, the electric and magnetic fields have a wavelength of 3,100 miles and have very low energy that does not cause heating or ionization. The 60 Hz fields do not radiate, unlike radio-frequency fields.

Electric fields around transmission lines are produced by electrical charges on the energized conductor. Electric field strength is directly proportional to the line's voltage; that is, increased voltage produces a stronger electric field. The electric field is inversely proportional to the distance from the conductors, so that the electric field strength declines as the distance from the conductor increases. The strength of the electric field is measured in units of kilovolts per meter (kV/m). The electric field around a transmission line remains practically steady and is not affected by the common daily and seasonal fluctuations in usage of electricity by customers.

Magnetic fields around transmission lines are produced by the level of current flow, measured in terms of amperes, through the conductors. The magnetic field strength also is directly proportional to the current; that is, increased amperes produce a stronger magnetic field. The magnetic field is inversely proportional to the distance from the conductors and therefore the strength of the magnetic field rapidly decreases as distance is increased from the conductor. Thus, like the electric field, the magnetic field strength declines as the distance from the conductor increases. Magnetic fields are expressed in units of milligauss (mG). The amperes and, therefore, the magnetic field around a transmission line fluctuate daily and seasonally as the usage of electricity varies.

Considerable research has been conducted over the last 30 years on the possible biological effects and human health effects from EMF. This research has produced many studies that offer no uniform conclusions about whether long-term exposure to EMF is harmful or not. In the absence of conclusive or evocative evidence, some states, California in particular, have chosen not to specify maximum acceptable levels of EMF. Instead, these states mandate a program of prudent avoidance whereby EMF exposure to the public would be minimized by encouraging electric utilities to use low-cost techniques to reduce the levels of EMF.

Additional information on EMF is provided in Appendix 5C.

5.5.2.2 Audible Noise

Corona is a function of the voltage of the line, the diameter of the conductor, and the condition of the conductor and suspension hardware. The electric field gradient is the rate at which the electric field changes and is directly related to the line voltage.

The electric field gradient is greatest at the surface of the conductor. Large-diameter conductors have lower electric field gradients at the conductor surface and, hence, lower corona than smaller conductors, everything else being equal. Also, irregularities (such as nicks and scrapes on the conductor surface) or sharp edges on suspension hardware concentrate the electric field at these locations and, thus, increase corona at these spots. Similarly, contamination on the conductor surface, such as dust or insects, can cause irregularities that are a source for corona. Raindrops, snow, fog, and condensation are also sources of irregularities. Corona typically becomes a design concern for transmission lines having voltages of 34-kV and above.

5.5.2.3 EMF and Audible Noise Assumptions

It is important that any discussion of EMF and audible noise include the assumptions used to calculate these values and to remember that EMF and audible noise in the vicinity of the power lines vary with regard to line design, line loading, distance from the line, and other factors. Both the electric field and audible noise depend upon line voltage, which remains nearly constant for a transmission line during normal operation. A worst-case voltage of 74-kV (70-kV + 5 percent) will be used in the calculations for the 70-kV line and 242-kV (230-kV + 5 percent) will be used in the calculations for the 230-kV lines.

The magnetic field is proportional to line loading (amperes), which varies as power plant generation is changed by the system operators to meet increases or decreases in demand for electrical power. Line loading values assumed for the EMF and audible noise studies were based on PG&E's 2004 Summer Peak Transmission Assessment Case. The CVEC plant is assumed to be operating at a net generation of 1,062 MW. The power will be transmitted away from the power plant. A power flow study was conducted, as described in Section 5.5.2.3.1, to calculate how the power is expected to distribute over the circuits. The calculated power flow values are tabulated in Section 5.5.2.3.1 and are used in the EMF and audible noise calculations.

Another important parameter for these studies is the phase arrangement of the lines, both existing and after the interconnection is made. The phasing (i.e., relative location of A, B, and C phases) on a multi-circuit structure may offer some field cancellation, which results in reduced magnetic field values at the right-of-way edge. Studies have shown that cross-phasing double-circuit lines provide magnetic field reduction when both circuits are carrying power in the same direction. In cross-phasing, the circuit on one side of the structure is configured, for example, with phases A, B and C arranged from top to bottom, while the other circuit is configured C, B, A from top to bottom.

The data and assumptions used for the EMF and audible noise studies can be noted from the discussions contained in the following paragraphs and the figures included in the following pages.

Figure 5.5-1 illustrates the plan view of the specific transmission lines represented by the four cross sections (A, B, C and D) that were included in the EMF and audible noise studies. Cross Sections A and B are representative of the indicated transmission lines without CVEC, and then with CVEC. These cross sections incorporate a double-circuit tower and are identical in all respects pertinent to the EMF and audible noise studies except for the current loads and direction of power flow. Cross Section A represents the corridor to the west of the Helm substation. Cross Section B represents the corridor to the east of the Helm substation. Cross Section C represents the indicated 70-kV line. Due to the location of the proposed CVEC, the existing 70-kV line would be rerouted. Once the transmission line is south of Colorado Avenue and the San Joaquin Valley Railroad, it is proposed that it turn and run parallel with the San Joaquin Valley Railroad at the northern end of the CVEC site for approximately 1,200 feet before turning south and eventually running in parallel with the proposed CVEC interconnect. Therefore, south of W. Springfield Avenue, this would move the 70-kV line approximately 840 feet to the east of its present location and away from S. Placer Avenue. It is assumed for this study that the rerouted line would be within the CVEC property line while running in parallel with the San Joaquin Valley Railroad. Cross Section D represents the proposed corridor for the CVEC interconnection project and would consist of two double-circuit steel poles for the 230-kV lines and a single-circuit steel pole for this portion of the rerouted 70-kV line. The proposed corridor would run southerly for approximately 1,300 feet toward the existing 230-kV lines and the Helm substation. Also, for purposes of calculating magnetic field, it is assumed in this study that the lowest clearance for all cross sections described above is 30 feet at mid-span.

Figure 5.5-2 is Cross Section A and represents the existing PG&E double-circuit lattice towers that carry the Panoche-Kearney and Panoche-Helm 230-kV lines as viewed looking west. The phasing configuration, conductor and shield wire used, and dimensions assumed for the EMF and audible noise studies are pictured. After the CVEC interconnection, Cross Section A is representative of the same location but would now be the proposed Panoche-Helm and Panoche-CVEC 230-kV lines, respectively.

Cross Section B, as depicted in Figure 5.5-3, shows the existing PG&E double-circuit lattice towers that presently carry the Panoche-Kearney and Helm-McCall 230-kV lines as viewed looking west. After the CVEC interconnection, Cross Section B is representative to this same section but depicts the proposed CVEC-Kearney (with McMullin Substation tap) and CVEC-McCall 230-kV lines. The phasing configuration, conductor and shield wire, and dimensions assumed for the EMF and audible noise studies are pictured.

Figure 5.5-4 is Cross Section C and represents the existing PG&E Helm-Kerman 70-kV line as viewed looking north. Due to the location of the proposed CVEC, the 70-kV line would be rerouted away from S. Placer Avenue once south of W. Springfield Avenue. The phasing configuration, conductor and shield wire, and dimensions assumed for the EMF and audible noise studies are pictured.

Cross Section D is illustrated in Figure 5.5-5 and represents the proposed CVEC interconnection corridor. This section consists of two 230-kV double-circuit steel poles for the CVEC interconnect and a single-circuit steel pole for this portion of the rerouted 70-kV line. Viewed looking north, the circuits are (as illustrated left to right) Panoche-CVEC, CVEC-Helm, CVEC Kearney (with McMullin tap), CVEC-McCall, and the rerouted Helm-Kerman 70-kV line. The phasing, conductor and shield wire, and dimensions assumed for the EMF and audible noise studies are pictured.

5.5.2.3.1 EMF Calculations

EMFs were calculated at one meter above flat terrain using ENVIRO, a TLWorkstation (TLW) program developed by the Electric Power Research Institute. Measurements for electric and magnetic fields at one meter above the ground surface are in accordance with the Institute of Electrical and Electronic Engineers (IEEE) standards. ENVIRO calculates the electric fields expressed as kilovolts per meter (kV/m) and the magnetic fields expressed in milliGauss (mG). The various inputs for the calculations include voltage, current load (amps), current angle (i.e., phasing), conductor type and spacing, number of subconductors, subconductor bundle symmetry, spatial coordinates of the conductors and shield wire, various labeling parameters, and other specifics. The field level is calculated perpendicular to the line and at mid-span where the overhead line sags closest to the ground (calculation point). The mid-span location, therefore, provides the maximum value for the field. Also using an ENVIRO mathematical model, audible noise is calculated at a 5-foot microphone height above flat terrain with information concerning rain, snow, and fog rates for daytime and nighttime hours as input. Audible noise is expressed in decibels, A-scale (dBA). Graphs contained in this report and the tables in Appendices 5E, 5F, and 5G were produced by importing ENVIRO data into Microsoft Excel.

A power flow model was developed from a PG&E data set (PG&E's 2004 Summer Peak Transmission Assessment Case). Two scenarios were calculated for comparison:

- Without the proposed CVEC operating (Base Case)
- With the proposed CVEC nominal net generation of 1,060 MW added (Study Plan)

The variations in the power flow for the studied cross sections are tabulated in the following Table 5.5-1.

TABLE 5.5-1
Normal Flows in the Vicinity of the Central Valley Energy Center (CVEC)
PG&E 2004 Summer Peak Transmission Assessment Case

Line	Normal Rating (Amps)	Line Flow Without CVEC (Amps) Heavy Summer	Line Flow With CVEC (Amps) Heavy Summer
Panoche - CVEC (Helm*)	741	163	-590
CVEC - Helm**	**	N/A	840
CVEC (Helm*) – McCall	741	59	455
Panoche – Helm (McMullin*)	823	223	645
CVEC (Panoche*) – Kearney (with McMullin tap)	N/A	N/A	697
Helm-Kerman 70-kV	322	133	174
Helm-San Joaquin Jct 70-kV	635	150	229
Helm-Stroud Jct 70-kV	322	33	190
Helm-Valley Nitrogen	635	8.3	8.3

Note: All flows are referenced from the first name listed for any line. For example, the values given for Panoche-CVEC are *from* Panoche *to* CVEC. Also note, based on the pertinence of their location, not all circuits considered for the power flow study were included in the EMF and audible noise studies.
* Indicates original line destination
** This line is part of the CVEC project and will be designed to have a sufficient rating.

5.5.2.3.2 Results of EMF and Audible Noise Calculations

Electric Field and Audible Noise

Line voltage and arrangement of the phases determine the electric field. The existing PG&E lines represented by Cross Sections A and B have no changes in either the voltage or the phasing. Therefore, the electric field in these vicinities will remain the same. The existing PG&E 70-kV section represented by Cross Section C shows a drop in electric field levels, which one would expect upon the rerouting of the line. The corridor represented by Cross Section D is the proposed CVEC interconnection to the existing 230-kV transmission lines and the rerouted 70-kV subtransmission line. Calculations for Cross Section D were extended to include most of Cross Section C in order to compare the “with CVEC” and “without CVEC” values. Locations of comparable values for Cross Section C from the Cross Section D calculations are at -710 feet, -640 feet, and -480 feet. These locations represent the -37.5-foot, +37.5-foot and +200-foot locations of Cross Section C, respectively. The analytical results of the electric field for all cross sections are shown in Appendix 5D. Graphical views are shown in Figures 5.5-6 through 5.5-9.

The highest levels of corona and, hence, audible noise will occur during foul weather when the line conductors are wet. For these conditions, the conductor will produce a small amount of corona. However, no change in audible noise over the existing 230-kV lines (Cross Sections A and B) will occur because the conductor and voltages will remain the same as those of the existing system. Extending Cross Section D calculations to include the location of Cross Section C, audible noise level calculations show an increase for Cross Section C. Locations of comparable values for Cross Section C from the Cross Section D calculations are at -710 feet, -640 feet, and -480 feet. These locations represent the -37.5-foot, +37.5-foot and +200-foot locations of Cross Section C, respectively. The analytical results for the audible noise calculations are shown in Appendix 5E. Graphical views are shown in Figures 5.5-10 through 13.

Magnetic Field

Again, calculations for Cross Section D were extended to include most of Cross Section C in order to compare the "with CVEC" and "without CVEC" values. Locations of comparable values for Cross Section C from the Cross Section D calculations are at -710 feet, -640 feet, and -480 feet. These locations coincide with the -37.5-foot, +37.5-foot and +200-foot locations of Cross Section C, respectively. The complete analytical results of the magnetic field calculations for all cross sections are provided in Appendix 5F, and a graphical view is given in Figures 5.5-14 through 17. Table 5.5-2 summarizes calculated values for the magnetic field. The ±37.5 feet from centerline coincides with the edge of right-of-way for Cross Sections A and B. For the existing Cross Section C magnetic field levels, a ±37.5 feet and a ±200 feet from centerline allow for a more thorough comparison for the "with CVEC" and "without CVEC" evaluation. The ±200 feet from the centerline for Cross Section D represents a fringe area wide enough to allow for the inclusion of the rerouted 70-kV line within the interconnection corridor. For each cross section, the distance is given where the maximum field value was located.

5.5.2.3.3 Transmission Line EMF Reduction

While the State of California does not set a statutory limit for electric and magnetic field levels, the California Public Utilities Commission (CPUC), which regulates electric transmission lines, mandates EMF reduction as a practicable design criterion for new and upgraded electrical facilities. As a result of this mandate, the regulated electric utilities, including PG&E, have developed their own design guidelines to reduce EMF at each new facility. The California Energy Commission (CEC), which regulates transmission lines to the point of connection, requires independent power producers (IPP) to follow the existing guidelines that are in use by local electric utilities or transmission-system owners.

TABLE 5.5-2
Magnetic Field (mG)
Calculated Field at Mid-span Perpendicular to Transmission Centerline

	Distance from Cross Section Centerline (feet) Given Below				
System at Peak Load	**-200**	**-37.5**	**Location of Maximum Value**	**+37.5**	**+200**
Cross Section A	**South of Centerline**		**-10**	**North of Centerline**	
Without CVEC Plant	n/a	18.93	29.64	11.92	n/a
			12.5		
With CVEC Plant	n/a	65.18	95.90	68.83	n/a
Cross Section B			**-15**		
Without CVEC Plant	n/a	18.83	27.42	7.71	n/a
			-10		
With CVEC Plant	n/a	58.91	90.82	33.81	n/a
Cross Section C	**West of Centerline**		**0**	**East of Centerline**	
Without CVEC Plant	.24	4.46	11.96	4.46	.24
With CVEC Plant	n/a	.23	n/a	.28	.46
Cross Section D			**-40**		
Without CVEC Plant	n/a	n/a	n/a	n/a	n/a
With CVEC Plant	1.90	n/a	107.15	n/a	6.89

In keeping with the goal of EMF reduction, the interconnection of the CVEC will be designed and constructed using the principles outlined in the PG&E publication, "Transmission Line EMF Guidelines." These guidelines explicitly incorporate the directives of the CPUC by developing design procedures compliant with Decision 93-11-013 and General Orders 95, 128, and 131-D. That is, when the transmission line structures, conductors, and rights-of-way are designed and routed according to the PG&E guidelines, the transmission line is consistent with the CPUC mandate.

From page 12 of the PG&E guidelines, the primary techniques for reducing EMF anywhere along the line are to:

1. Increase the distance between conductors and EMF sensors
2. Reduce the spacing between the line conductors
3. Minimize the current on the line
4. Optimize the configuration of the phases (A, B, C)

Anticipated EMF levels have been calculated for the CVEC interconnection as preliminarily designed. The CEC requires actual measurements of pre-interconnection background EMF for comparison with measurements of post-interconnection EMF levels. If required, the pre- and post-interconnection verification measurements will be made consistent with IEEE guidelines and will provide sample readings of EMF at the edge of right-of-way. Additional measurements will be made upon request for locations of particular concern.

5.5.2.3.4 Conclusion on EMF and Audible Noise

In conclusion, for Cross Sections A and B, there is no change to the existing lines' electric field and audible noise levels, as there is no change to the voltage or line configurations. There is an increase, though, of magnetic field levels because there is an increase of current load. No physical changes to these existing lines are anticipated except at the area between the Helm substation and the proposed CVEC due to the physical interconnection into the CVEC.

Cross Section C has a decrease in electric field levels since the line would be rerouted. An increase in audible noise levels was calculated and is due to the fact that corona, which can produce audible noise, is usually only a nuisance issue with transmission lines at 345-kV and above. In other words, the higher the transmission line voltage, the higher the audible noise levels will calculate to — whether considered to be at a nuisance level or not. The higher audible noise levels calculated for the Cross Section C location with the CVEC are below the levels calculated for the existing 230-kV lines depicted in Cross Section A and Cross Section B. The magnetic field shows a decrease upon rerouting the 70-kV line.

Calculated values for Cross Section D show a maximum electric field level of 2.455-kV/m, which is 0.066-kV/m below the calculated maximum level for the existing 230-kV lines considered in Cross Sections A and B. The maximum audible noise level calculated is 63.0 dB, which is 1.5 dBA above the existing 230-kV lines. There is virtually no difference in these calculated audible noise levels. In order to achieve a reduced EMF design for Cross Section D, the Helm-CVEC circuit was assumed to cross-phase with the Panoche-CVEC circuit that would be strung on the same double-circuit pole structure within the corridor. This is a no-cost EMF reduction and is consistent with the principles outlined in the PG&E publication, "Transmission Line EMF Guidelines." For the proposed interconnection and the rerouted 70-kV line, the hardware used to connect the conductors to the structures will be of low-corona design. Special care will be employed during stringing of the conductor to minimize nicks and scrapes to the conductor. These actions will ensure a low-corona design.

5.5.2.4 Induced Current and Voltages

A conducting object such as a vehicle or person in an electric field will have induced voltages and currents. The strength of the induced current will depend upon the electric field strength, the size and shape of the conducting object, and the object-to-ground resistance. Examples of measured induced currents in a 1-kV/m electric field are about 0.016 milliamperes (mA) for a person, about 0.41 mA for a large school bus, and about 0.63 mA for a large trailer truck.

When a conducting object is isolated from the ground and a grounded person touches the object, a perceptible current or shock may occur as the current flows to ground. Shocks are classified as below perception, above perception, secondary, and primary. The mean perception level is 1.0 mA for a 180-pound man and 0.7 mA for a 120-pound woman. Secondary shocks cause no direct physiological harm, but may annoy a person and cause involuntary muscle contraction. The lower average secondary-shock level for an average-sized man is about 2 mA.

Primary shocks can be harmful. Their lower level is described as the current at which 99.5 percent of subjects can still voluntarily “let go” of the shocking electrode. For the 180-pound man this is 9 mA; for the 120-pound woman, 6 mA; and for children, 5 mA. The NESC specifies 5 mA as the maximum allowable short-circuit current to ground from vehicles, trucks, and equipment near transmission lines.

The mitigation for hazardous and nuisance shocks is to ensure that metallic objects on or near the right-of-way are grounded and that sufficient clearances are provided at roadways and parking lots to keep electric fields at these locations sufficiently low to prevent vehicle short-circuit currents from exceeding 5 mA.

Magnetic fields can also induce voltages and currents in conducting objects. Typically, this requires a long metallic object, such as a wire fence or above-ground pipeline that is grounded at only one location. A person who closes an electrical loop by grounding the object at a different location will experience a shock similar to that described above for an ungrounded object. Mitigation for this problem is to ensure multiple grounds on fences or pipelines, especially those that are orientated parallel to the transmission line.

Where railroads are crossed or are parallel to the transmission line, coordination is required with the railroad company to ensure that the magnetically induced voltages and currents in the rails do not interfere with railroad signal and communications circuits, which often are transmitted through the rails. An approximate 1,200-foot section of the rerouted 70-kV line would be located along the northeast side of Colorado Ave. north of the proposed CVEC site. Upon final design for the location and various other specifics of the rerouted line, a study as to any possible electrical interference will be conducted if requested. The proposed rerouting of the 70-kV line will be constructed in conformance with GO-52.

The proposed 230-kV transmission interconnection will be constructed in conformance with GO-95 and 8 CCR 2700 requirements. Therefore, hazardous shocks are unlikely to occur as a result of project construction or operation.

5.5.3 Aviation Safety

Federal Aviation Administration (FAA) Regulations, Part 77 establishes standards for determining obstructions in navigable airspace and sets forth requirements for notification of proposed construction. These regulations require FAA notification for any construction over 200 feet in height above ground level. Also, notification is required if the obstruction is less than specified heights and falls within any restricted airspace in the approach to airports. For airports with runways longer than 3,200 feet, the restricted space extends 20,000 feet (3.3 nautical miles) from the runway. For airports with runways measuring 3,200 feet or less, the restricted space extends 10,000 feet (1.7 nautical miles). For heliports, the restricted space extends 5,000 feet (0.8 nautical mile).

There are two airfields within 10 nautical miles of the proposed CVEC site: Du Bois Ranch Air Port, 7.1 nautical miles to the northeast near Kerman, California, and San Joaquin Airport, approximately 2 nautical miles west-northwest of the proposed site. As no element proposed for the interconnecting transmission line is taller than 200 feet, the DuBois Ranch Airport is clearly outside the notification requirements discussed above. The San Joaquin Airport has only a single treated dirt runway approximately 2,500 feet long. It is oriented in a north-northwest/south-southeast direction. The length of the proposed interconnecting 230-kV transmission line would extend approximately 1,600 feet south toward the Helm Substation. However, this proposed alignment of the transmission line will place the closest structure no closer than approximately 13,000 feet to the airport. This places the structures of the interconnection outside the sector of restricted space around the airport.

Although it may be necessary to notify the FAA due to other tall elements of the project, the height of the transmission structures (125 feet maximum) does not trigger a review. As a result of their location in relation to the San Joaquin Airport, and height, the structures of the proposed electrical transmission interconnection will pose no deterrent to aviation safety as defined in the FAA regulations.

5.5.4 Fire Hazards

The proposed double-circuit 230-kV transmission interconnection and the re-routed 70-kV lines will be designed, constructed, and maintained in accordance with GO-95, which establishes clearances from other man-made and natural structures as well as tree-trimming requirements to mitigate fire hazards. It is not anticipated that the right-of-way for the proposed interconnecting transmission line will have any trees or brush due to its present agricultural land-use activities (see Figure 5.1-1). The Applicant will contract with trained and qualified maintenance personnel to maintain the interconnection corridor and immediate area of the switchyard in accordance with accepted industry practices that will include recognition and abatement of any fire hazards.

5.6 Applicable Laws, Ordinances, Regulations, and Standards

This section provides a list of applicable laws, ordinances, regulations, and standards (LORS) that apply to the proposed transmission line, substations and engineering. The following compilation of LORS is in response to Section (h), of Appendix B attached to Article 6, of Chapter 6, of Title 20 of the California Code of Regulations. Inclusion of these data is further outlined in the CEC's publication entitled "Rules of Practice and Procedure & Power Plant Site Certification Regulations."

5.6.1 Design and Construction

Table 5.6-1 lists the applicable LORS for the design and construction of the proposed transmission line and substations.

TABLE 5.6-1
Design and Construction LORS

LORS	Applicability	AFC Reference
General Order 95 (GO-95), CPUC, "Rules for Overhead Electric Line Construction"	California Public Utility Commission (CPUC) rule covers required clearances, grounding techniques, maintenance, and inspection requirements.	Section 5.2.2.1 Section 5.2.2.2 Section 5.2.2.3
Title 8 California Code of Regulations (CCR), Section 2700 et seq. "High Voltage Electrical Safety Orders"	Establishes essential requirements and minimum standards for installation, operation, and maintenance of electrical installation and equipment to provide practical safety and freedom from danger.	Section 5.2.2.1 Section 5.2.2.2 Section 5.2.2.3
General Order 128 (GO-128), CPUC, "Rules for Construction of Underground Electric Supply and Communications Systems"	Establishes requirements and minimum standards to be used for the station AC power and communications circuits.	Section 5.2.2.1

TABLE 5.6-1
Design and Construction LORS

LORS	Applicability	AFC Reference
General Order 52 (GO-52), CPUC, "Construction and Operation of Power and Communication Lines"	Applies to the design of facilities to provide or mitigate inductive interference.	Section 5.2.2.2 Section 5.5.2.1 Section 5.5.2.2 Section 5.5.2.3.3 Section 5.5.2.4
ANSI/IEEE 693 "IEEE Recommended Practices for Seismic Design of Substations"	Provides recommended design and construction practices.	Section 5.2.2.1 Section 5.2.2.2
IEEE 1119 "IEEE Guide for Fence Safety Clearances in Electric-Supply Stations"	Provides recommended clearance practices to protect persons outside the facility from electric shock.	Section 5.2.2 Section 5.5.1
IEEE 998 "Direct Lightning Stroke Shielding of Substations"	Provides recommendations to protect electrical system from direct lightning strokes.	Section 5.2.2.1 Section 5.2.2.2
IEEE 980 "Containment of Oil Spills for Substations"	Provides recommendations to prevent release of fluids into the environment.	Section 5.2.2.1 Section 5.2.2.2
Suggestive Practices for Raptor Protection on Powerlines, April 1996	Provides guidelines to avoid or reduce raptor collision and electrocution	Section 5.2.2.3

5.6.2 Electric and Magnetic Fields (EMF)

The applicable LORS pertaining to electric and magnetic field interference are tabulated in Table 5.6-2.

TABLE 5.6-2
Electric and Magnetic Field LORS

LORS	Applicability	AFC Reference
Decision 93-11-013 of the CPUC	CPUC position on EMF reduction.	Section 5.5.2 Section 5.5.2.3.3
General Order 131-D (GO-131), CPUC, Rules for Planning and Construction of Electric Generation, Line, and Substation Facilities in California	CPUC construction-application requirements, including requirements related to EMF reduction.	Section 5.2.2 Section 5.5.1 Section 5.5.2
Pacific Gas & Electric Company, "Transmission Line EMF Design Guidelines"	Large local electric utility's guidelines for EMF reduction through structure design, conductor configuration, circuit phasing, and load balancing. (In keeping with CPUC D.93-11-013 and GO-131)	Section 5.2.2 Section 5.5.2
ANSI/IEEE 644-1994 "Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines"	Standard procedure for measuring EMF from an electric line that is in service	Section 5.5.2

5.6.3 Hazardous Shock

Table 5.6-3 lists the LORS regarding hazardous shock protection that apply to the project.

TABLE 5.6-3
Hazardous Shock LORS

LORS	Applicability	AFC Reference
8 CCR 2700 et seq. "High Voltage Electrical Safety Orders"	Establishes essential requirements and minimum standards for installation, operation and maintenance of electrical equipment to provide practical safety and freedom from danger.	Section 5.2.2.1 Section 5.2.2.2 Section 5.2.2.3 Section 5.5.1
ANSI/IEEE 80 "IEEE Guide for Safety in AC Substation Grounding"	Presents guidelines for assuring safety through proper grounding of AC outdoor substations.	Section 5.2.2.1 Section 5.2.2.2 Section 5.5.1
National Electrical Safety Code (NESC), ANSI C2, Section 9, Article 92, Paragraph E; Article 93, Paragraph C.	Covers grounding methods for electrical supply and communications facilities.	Section 5.2.2.1 Section 5.2.2.2 Section 5.2.2.3 Section 5.5.2.1 Section 5.5.2.2

5.6.4 Communications Interference

The applicable LORS pertaining to communication interference are tabulated in Table 5.6-4.

TABLE 5.6-4
Communications Interference LORS

LORS	Applicability	AFC Reference
47 CFR 15.25, "Operating Requirements, Incidental Radiation"	Prohibits operations of any device emitting incidental radiation that causes interference to communications. The regulation also requires mitigation for any device that causes interference.	Section 5.2.2 Section 5.5.2.1 Section 5.5.2.2 Section 5.5.2.3.3 Section 5.5.2.4
General Order 52 (GO-52), CPUC	Covers all aspects of the construction, operation, and maintenance of power and communication lines and specifically applies to the prevention or mitigation of inductive interference.	Section 5.2.2 Section 5.2.2.1 Section 5.5.2.2 Section 5.5.2.4
CEC staff, Radio Interference and Television Interference (RI-TVI) Criteria (Kern River Cogeneration) Project 82-AFC-2, Final Decision, Compliance Plan 13-7	Prescribes the CEC's RI-TVI mitigation requirements, developed and adopted by the CEC in past siting cases.	Section 5.2.2.1 Section 5.2.2.2 Section 5.5.2.2

5.6.5 Aviation Safety

Table 5.6-5 lists the aviation safety LORS that may apply to the proposed construction and operation of the CVEC.

TABLE 5.6-5
Aviation Safety LORS

LORS	Applicability	AFC Reference
Title 14 CFR Part 77 “Objects Affecting Navigable Airspace”	Describes the criteria used to determine whether a “Notice of Proposed Construction or Alteration” (NPCA, FAA Form 7460-1) is required for potential obstruction hazards.	Section 5.2.2.1 Section 5.2.2.2 Section 5.2.2.3 Section 5.5.3
FAA Advisory Circular No. 70/7460-1G, “Obstruction Marking and Lighting”	Describes the FAA standards for marking and lighting of obstructions as identified by Federal Aviation Regulations Part 77.	Section 5.2.2.1 Section 5.2.2.2 Section 5.2.2.3 Section 5.5.3
Public Utilities Code (PUC), Sections 21656-21660	Discusses the permit requirements for construction of possible obstructions in the vicinity of aircraft landing areas, in navigable airspace, and near the boundary of airports.	Section 5.2.2.1 Section 5.2.2.2 Section 5.2.2.3 Section 5.5.3

5.6.6 Fire Hazards

Table 5.6-6 tabulates the LORS governing fire hazard protection for the CVEC project.

TABLE 5.6-6
Fire Hazard LORS

LORS	Applicability	AFC Reference
14 CCR Sections 1250-1258, “Fire Prevention Standards for Electric Utilities”	Provides specific exemptions from electric pole and tower firebreak and electric conductor clearance standards, and specifies when and where standards apply.	Section 5.2.2.2 Section 5.5.4
ANSI/IEEE 80 “IEEE Guide for Safety in AC Substation Grounding”	Presents guidelines for assuring safety through proper grounding of AC outdoor substations.	Section 5.2.2.1 Section 5.2.2.2 Section 5.5.4
General Order 95 (GO-95), CPUC, “Rules for Overhead Electric Line Construction” Section 35	CPUC rule covers all aspects of design, construction, operation, and maintenance of electrical transmission line and fire safety (hazards).	Section 5.2.2 Section 5.5.4

5.6.7 Jurisdiction

Table 5.6-7 identifies national, state, and local agencies with jurisdiction to issue permits or approvals, conduct inspections, and/or enforce the above referenced LORS. Table 5.6-7 also identifies the associated responsibilities of these agencies as they relate to the construction and operation of the CVEC.

TABLE 5.6-7
Jurisdiction

Agency or Jurisdiction	Responsibility
California Energy Commission (CEC)	Jurisdiction over new transmission lines associated with thermal power plants that are 50 megawatts (MW) or more. (PRC 25500)
CEC	Jurisdiction of lines out of a thermal power plant to the interconnection point to the utility grid. (Public Resources Code [PRC] 25107)
CEC	Jurisdiction over modifications of existing facilities that increase peak operating voltage or peak kilowatt capacity 25 percent. (PRC 25123)
CPUC	Regulates construction and operation of overhead transmission lines. (General Order No. 95 and 131-D) (those not regulated by the CEC)
CPUC	Regulates construction and operation of power and communications lines for the prevention of inductive interference. (General Order No. 52)
Federal Aviation Administration (FAA)	Establishes regulations for marking and lighting of obstructions in navigable airspace. (AC No. 70/7460-1G)
Local Electrical Inspector	Jurisdiction over safety inspection of electrical installations that connect to the supply of electricity. (NFPA 70)
California Independent System Operator (CAISO)	Provides Final Interconnection Approval
County of Fresno	Establishes and enforces zoning regulations for specific land uses. Issues variances in accordance with zoning ordinances. Issues and enforces certain ordinances and regulations concerning fire prevention and electrical inspection.

5.7 References

California Public Service Commission, General Order 95-Rules for Overhead Electric Line Construction.

California Public Service Commission, General Order 128-Rules for Construction of Underground Electric Supply and Communications Systems.

California Public Service Commission, General Order 52-Construction and Operation of Power and Communication Lines.

California Public Service Commission, General Order 131D-Rules for Planning and Construction of Electric Generation, Line, and Substation Facilities.

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Power Flow Case provided by PG&E.

Transmission Line Reference Book, 115-138-kV Compact Line Design, Electric Power Research Institute, Palo Alto, California, 1978.

Transmission Line Reference Book, 345-kV and Above, Electric Power Research Institute, Palo Alto, California, 1975.

Proposed Interconnection Alignment
Existing 230 kV Transmission Line
Proposed 70 kV Transmission Line Reroute Alignment
Existing 70 kV Transmission Line
Proposed Central Valley Energy Center Site
Existing Tower & Tower Number
Proposed Dead-End Structure

*** ( )** indicates the previous line designation.

Basemap Source: *Delorme 3D Topoquads, USGS 7.5 Minute Quadrangle Maps.*

N W E S

Scale: 1" = 750'

0 375 750

Feet

California

Map Area

Figure 5.1-1

Regional Transmission Resources in the Vicinity of the Proposed Central Valley Energy Center and Proposed Interconnection Route Alignment

Proposed Central Valley Energy Center

San Joaquin, California

Calpine Corporation

Prepared By: August 13, 2001

CAI Commonwealth Associates Inc.

Jackson, Michigan

engineers • consultants • construction managers

Proposed Interconnection Alignment
Existing 230 kV Transmission Line
Proposed 70 kV Transmission Line Reroute Alignment
Existing 70 kV Transmission Line
Proposed Central Valley Energy Center Site
Existing Tower & Tower Number
Proposed Dead-End Structure

*** ( )** indicates the previous line designation.

Basemap Source: *Delorme 3D Topoquads, USGS 7.5 Minute Quadrangle Maps.*

Figure 5.1-2

Regional Transmission Resources in the Vicinity of the Proposed Central Valley Energy Center and Proposed Interconnection Route Alignment

Proposed Central Valley Energy Center

San Joaquin, California

Calpine Corporation

October 4, 2001

Prepared By:

CAI Commonwealth Associates Inc.

Jackson, Michigan

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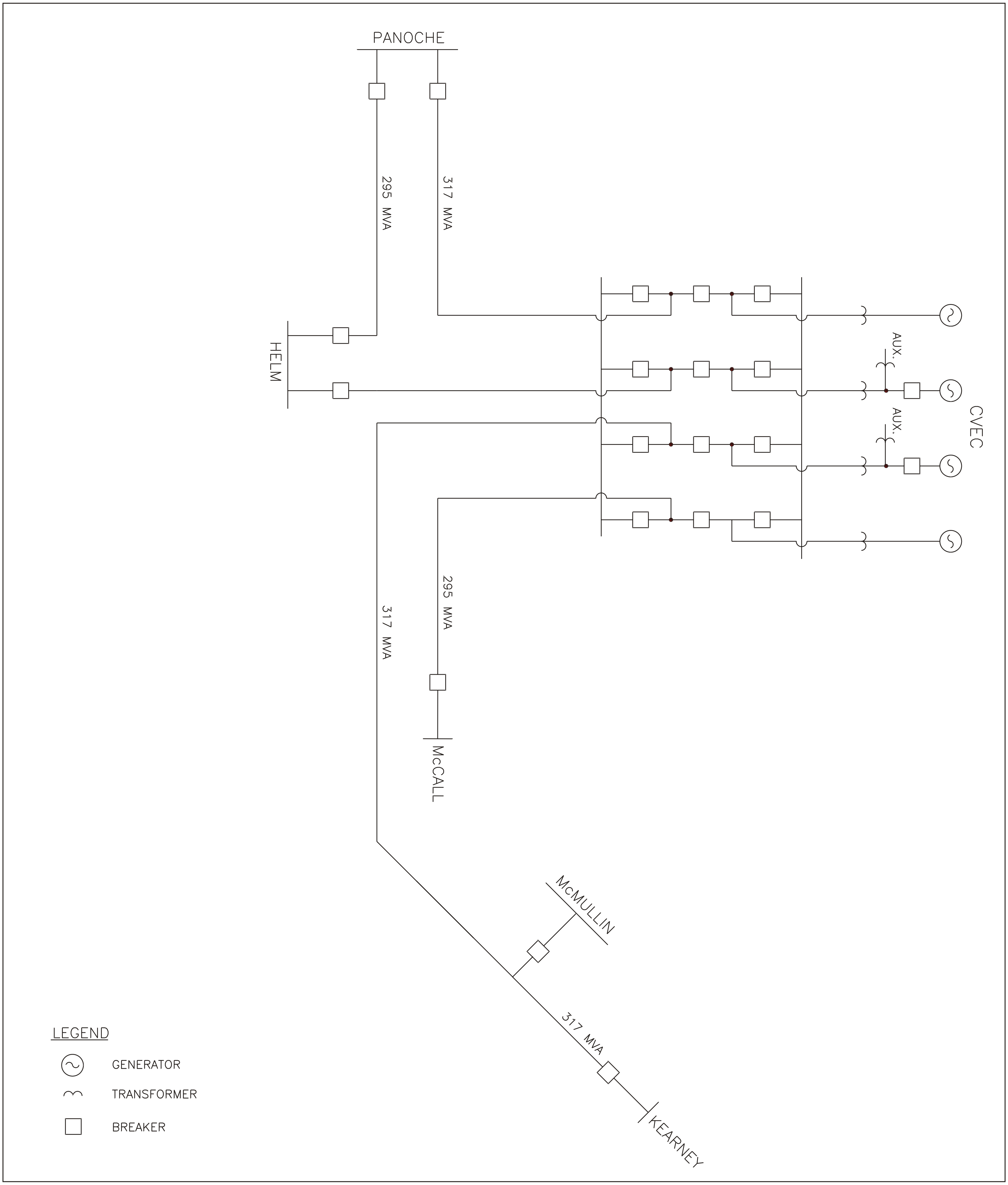
5.1-3A
Oversize Drawings Provided in Hardcopy Format Only

5.1-3B
Oversize Drawings Provided in Hardcopy Format Only



One-Line Schematic of the Proposed CVEC 230 kV Interconnection

Figure 5.2-1

August 21, 2001

Central Valley Energy Center - Calpine Corporation

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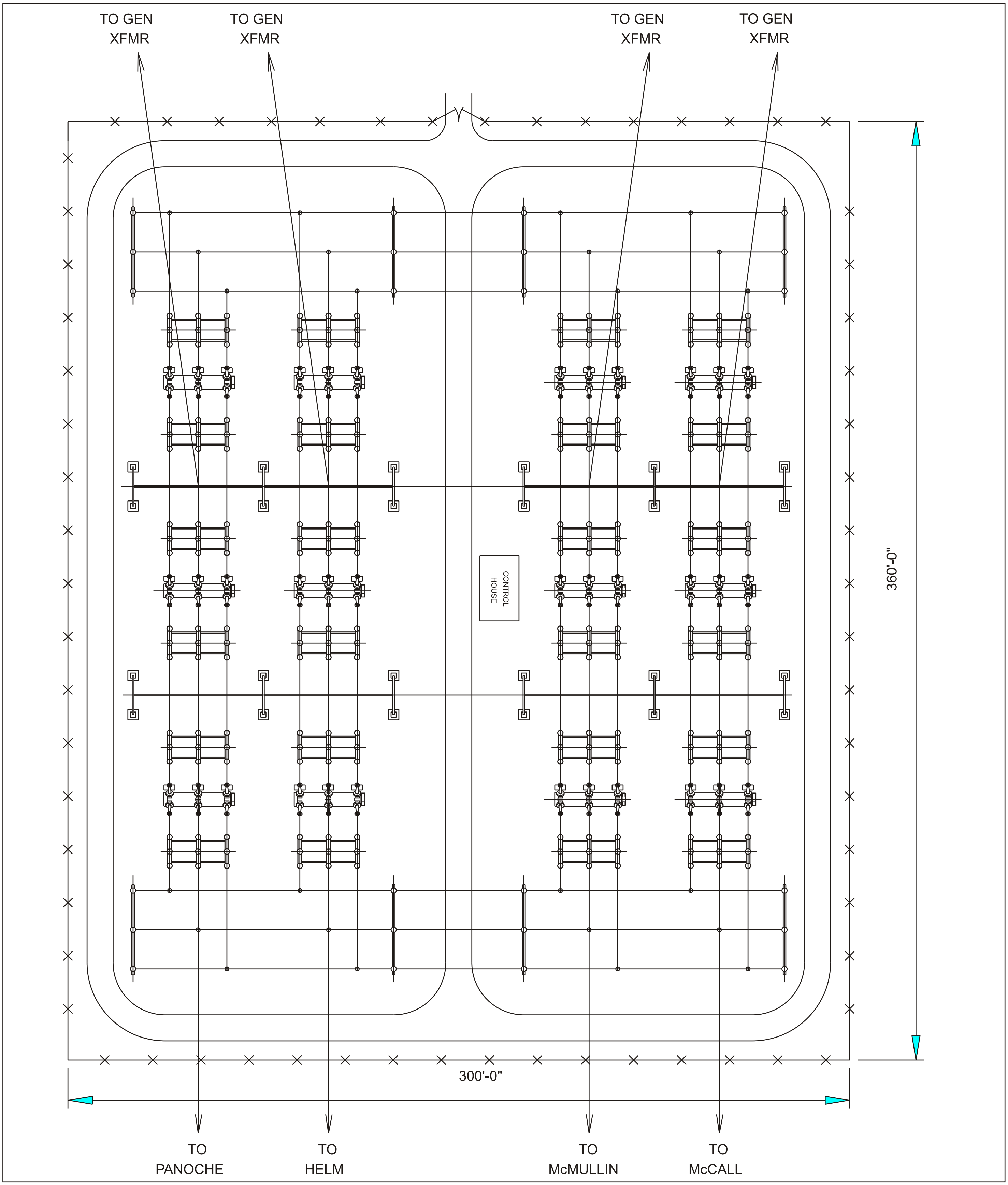

Layout of the Proposed CVEC 230 kV Switchyard

Figure 5.2-2

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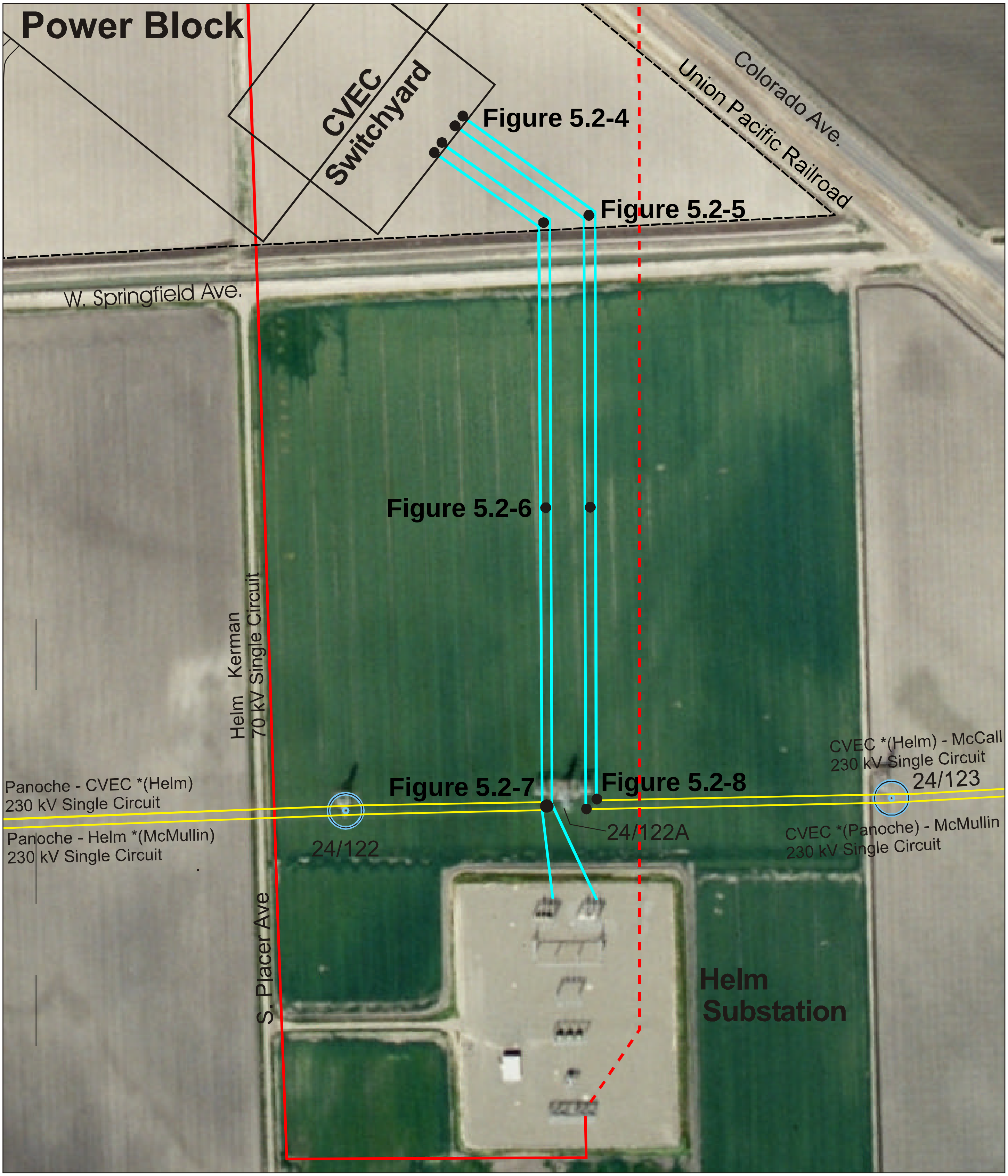

Proposed Interconnection Alignment
Existing 230 kV Transmission Line
Proposed 70 kV Transmission Line Reroute Alignment
Existing 70 kV Transmission Line
Proposed Central Valley Energy Center Site
Existing Tower & Tower Number
Proposed Tower Location
Figure 6.2-X Conceptual Tower Design (Text)

*** ( )** indicates the previous line designation.
Basemap Source: *Color aerial photography.*

N W E S

Scale: 1" = 300'
0 150 300
Feet

California
Map Area

Figure 5.2-3
Tower Placement
Proposed Interconnection
Proposed Central Valley Energy Center
San Joaquin, California
Calpine Corporation
October 4, 2001

Prepared By:
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Jackson, Michigan
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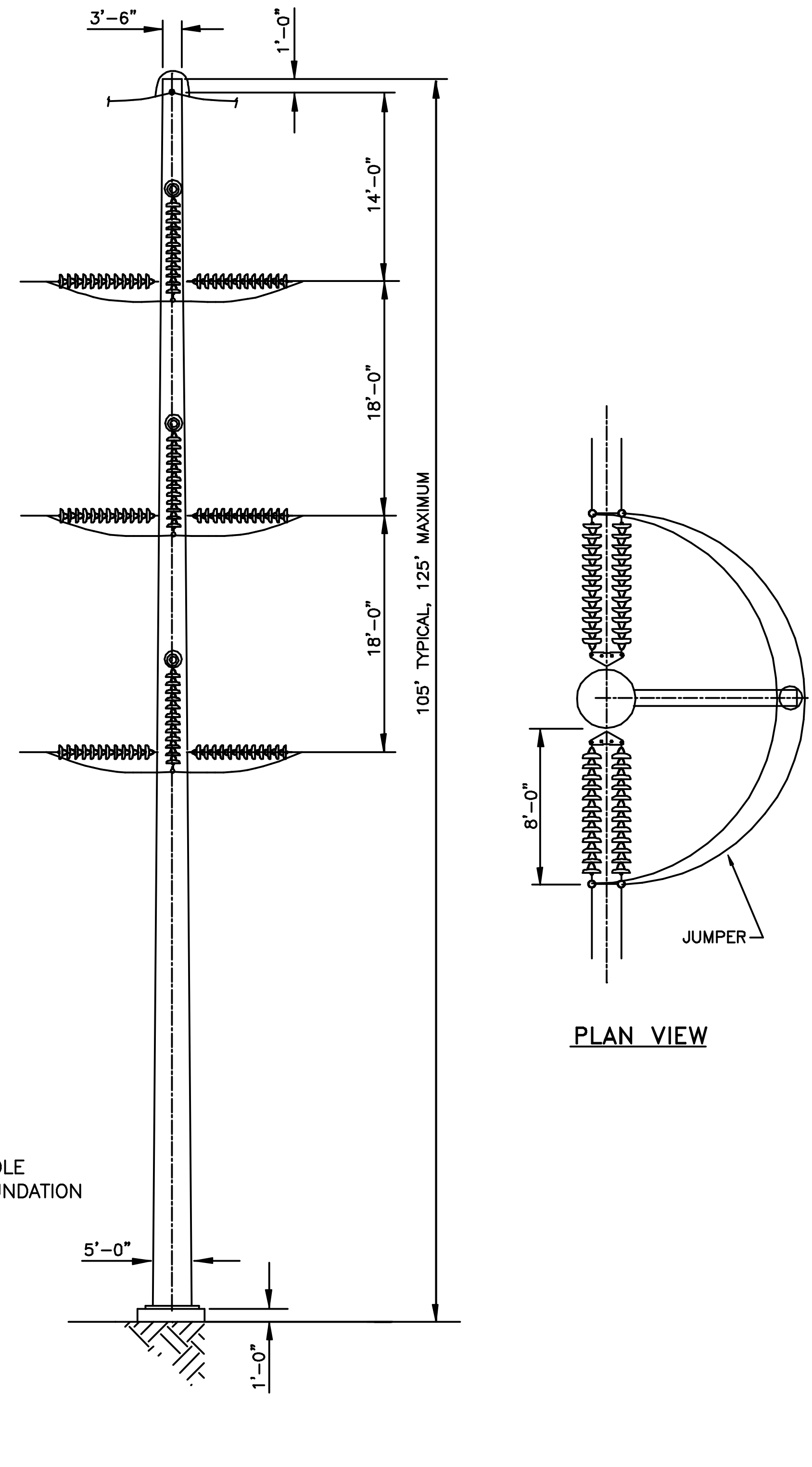

230 kV Single-Circuit Terminal Dead-End Structure

Central Valley Energy Center - Calpine Corporation

Figure 5.2-4

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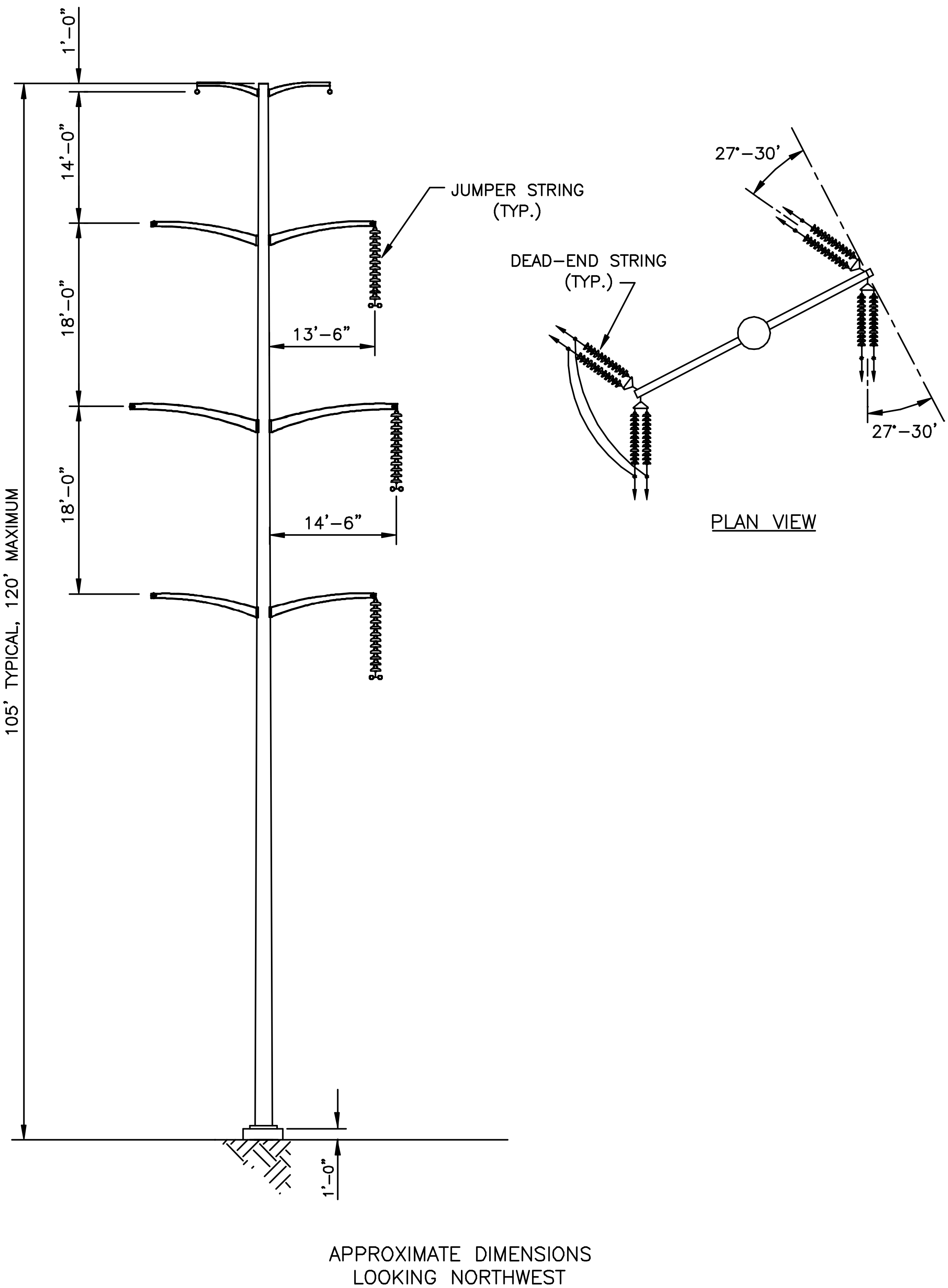

230 kV Double-Circuit Non-Terminal Dead-End Structure

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Figure 5.2-5

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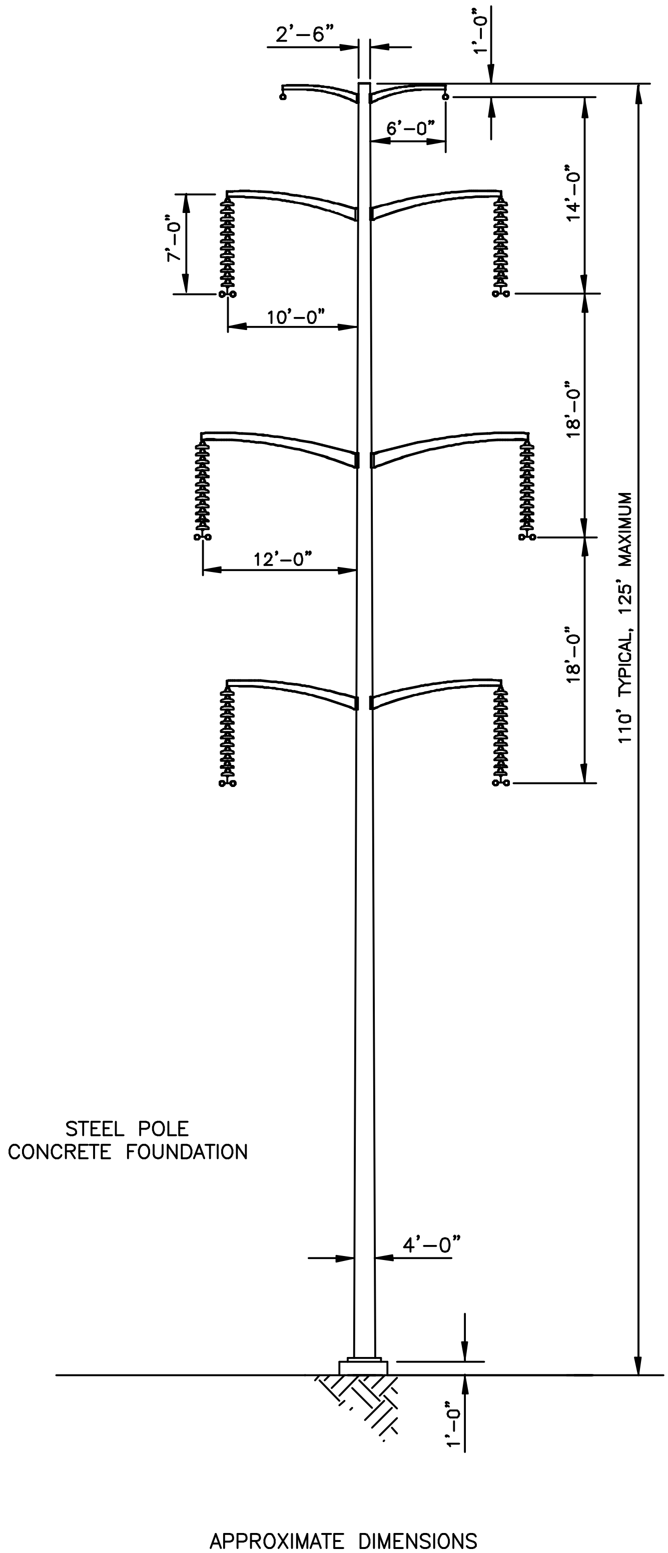

230 kV Double-Circuit Tangent Structure

Figure 5.2-6

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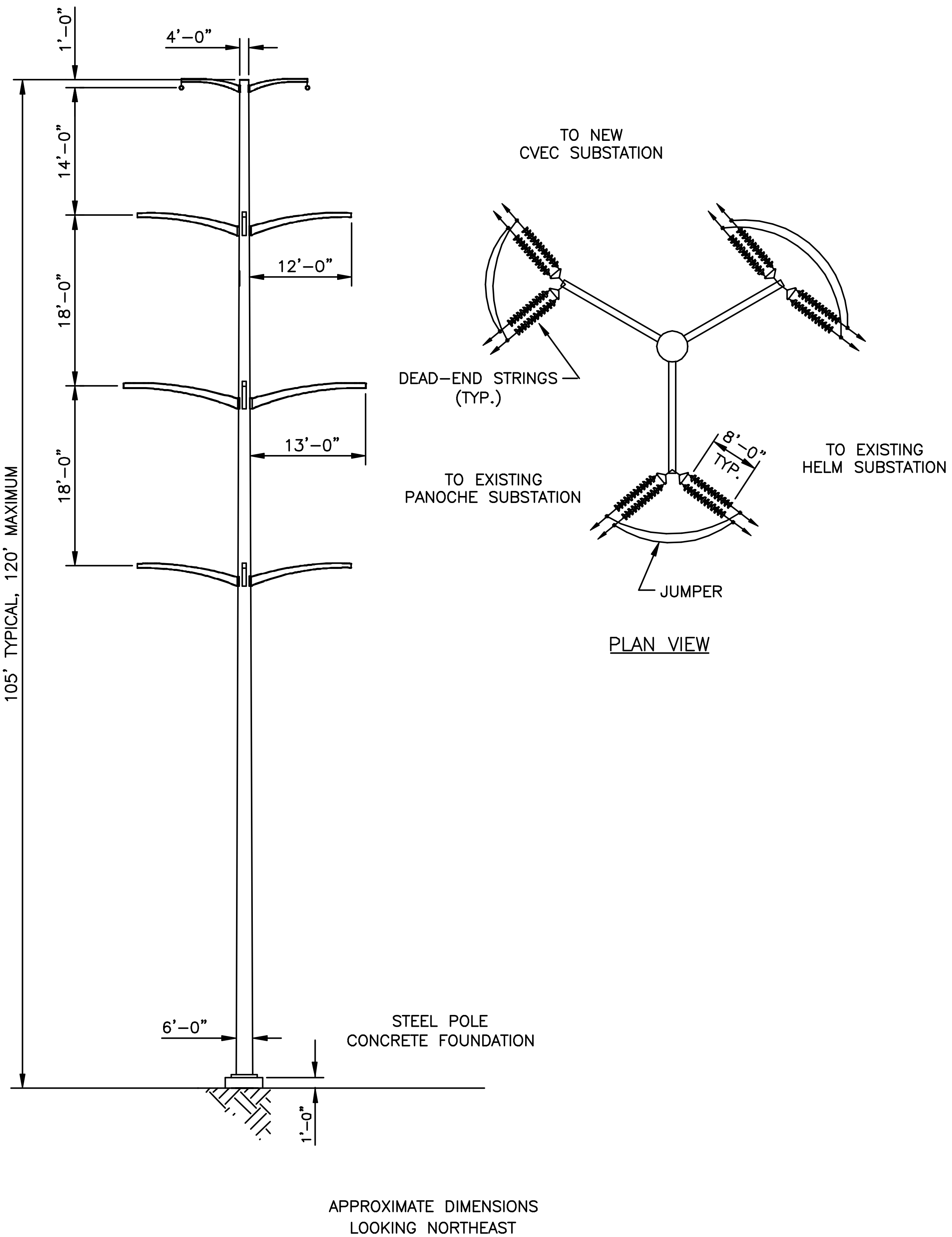

230 kV 3-Way Terminal Dead-End Structure

Figure 5.2-7

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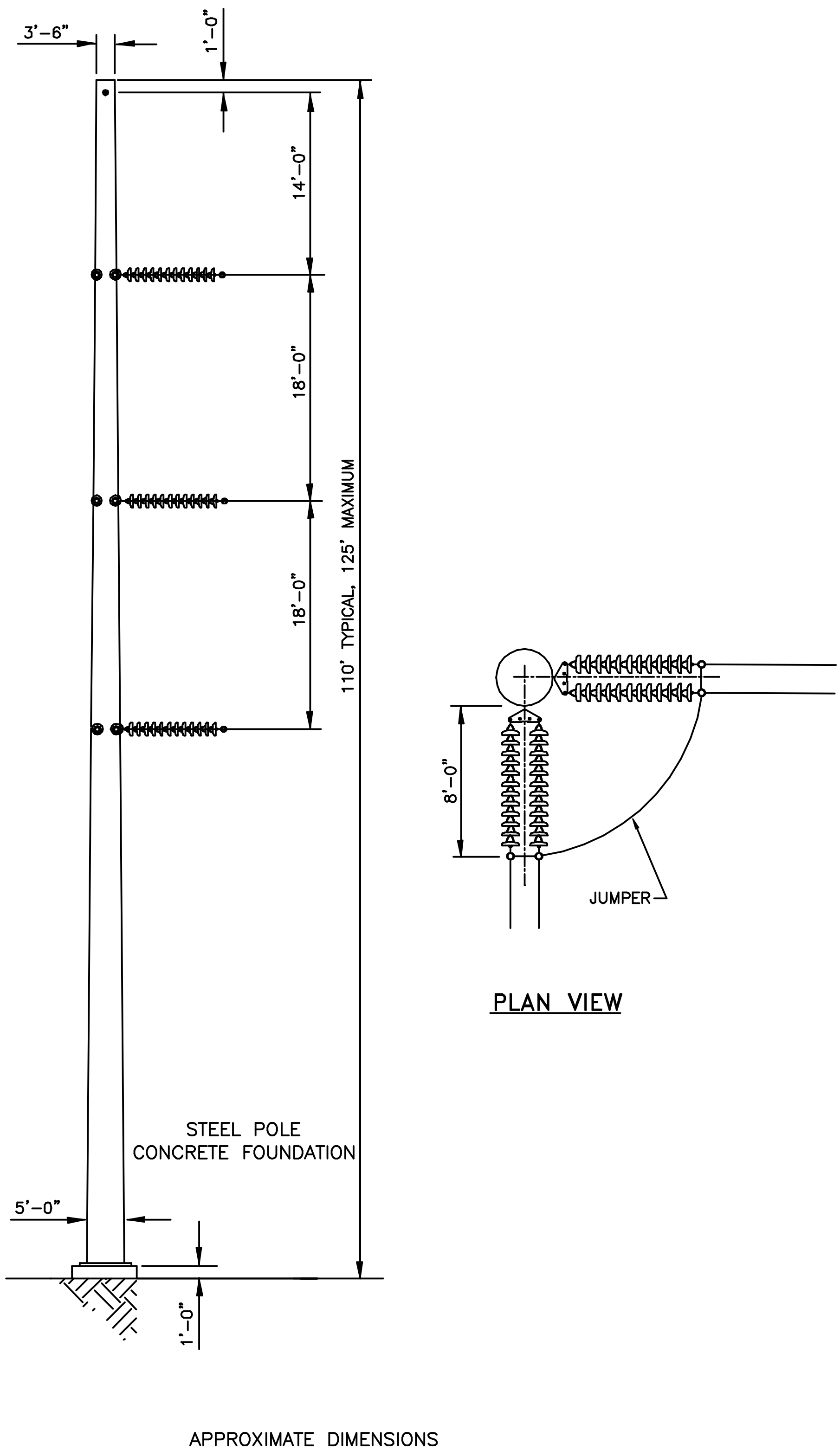

230 kV 90° Angle Terminal Dead-End Structure (Single-Circuit)

Figure 5.2-8

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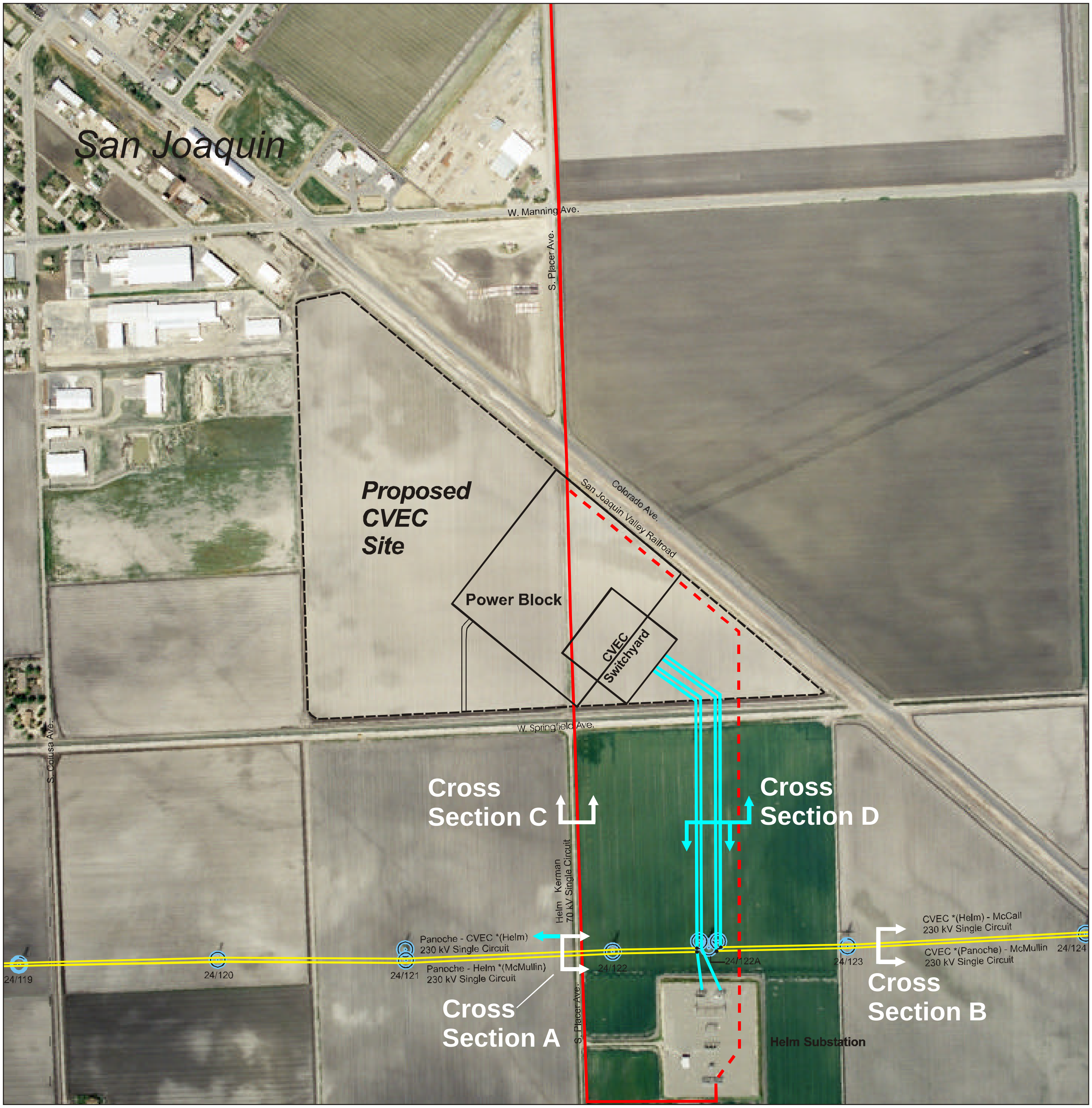

Proposed Interconnection Alignment
Existing 230 kV Transmission Line
Proposed 70 kV Transmission Line Reroute Alignment
Existing 70 kV Transmission Line
Proposed Central Valley Energy Center Site
Existing Tower & Tower Number
Proposed Dead-End Structure

* ( ) indicates the previous line designation.

Basemap Source: *Delorme 3D Topoquads, USGS 7.5 Minute Quadrangle Maps.*

N W E S

Scale: 1" = 750'
0 375 750
Feet

Figure 5.5-1
EMF Study Cross Sections

Proposed Central Valley Energy Center
San Joaquin, California
Calpine Corporation
August 21, 2001

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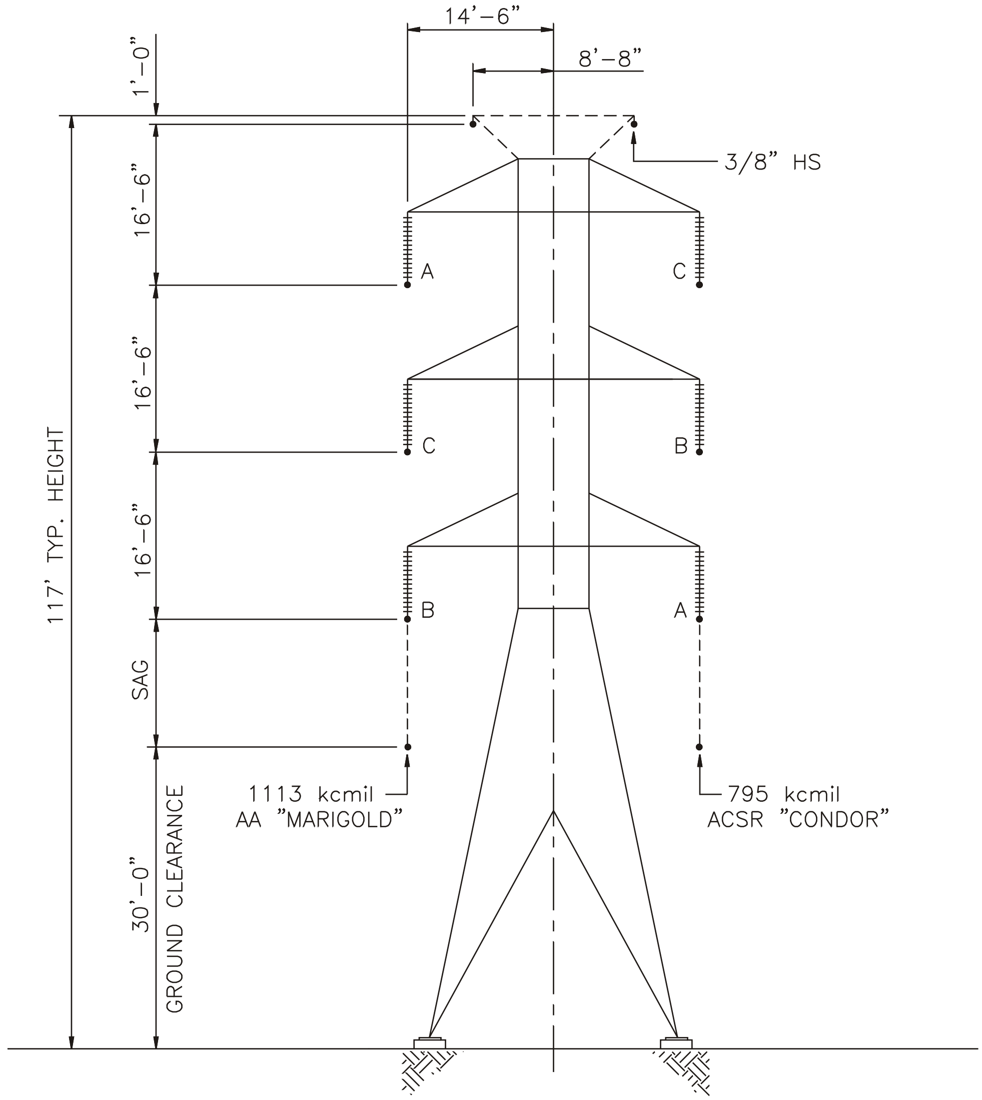
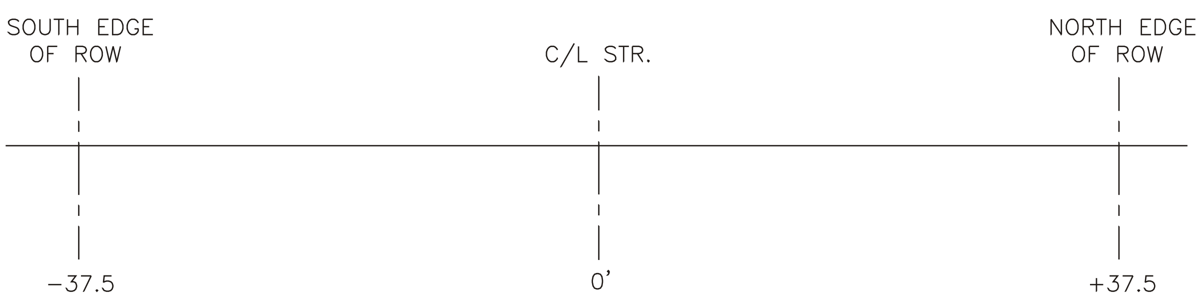
230 kV DOUBLE CIRCUIT LATTICE TOWER



STUDY ASSUMPTIONS FOR EMF CALCULATIONS
VIEW LOOKING WEST



NOT TO SCALE
ALL DIMENSIONS AND PHASING ARE ESTIMATES
AND ARE PROVIDED FOR PURPOSES OF CALCULATING EMF ONLY

Cross Section A
230 kV Typical Double-Circuit Structure

Central Valley Energy Center -
Calpine Corporation

Figure 5.5-2

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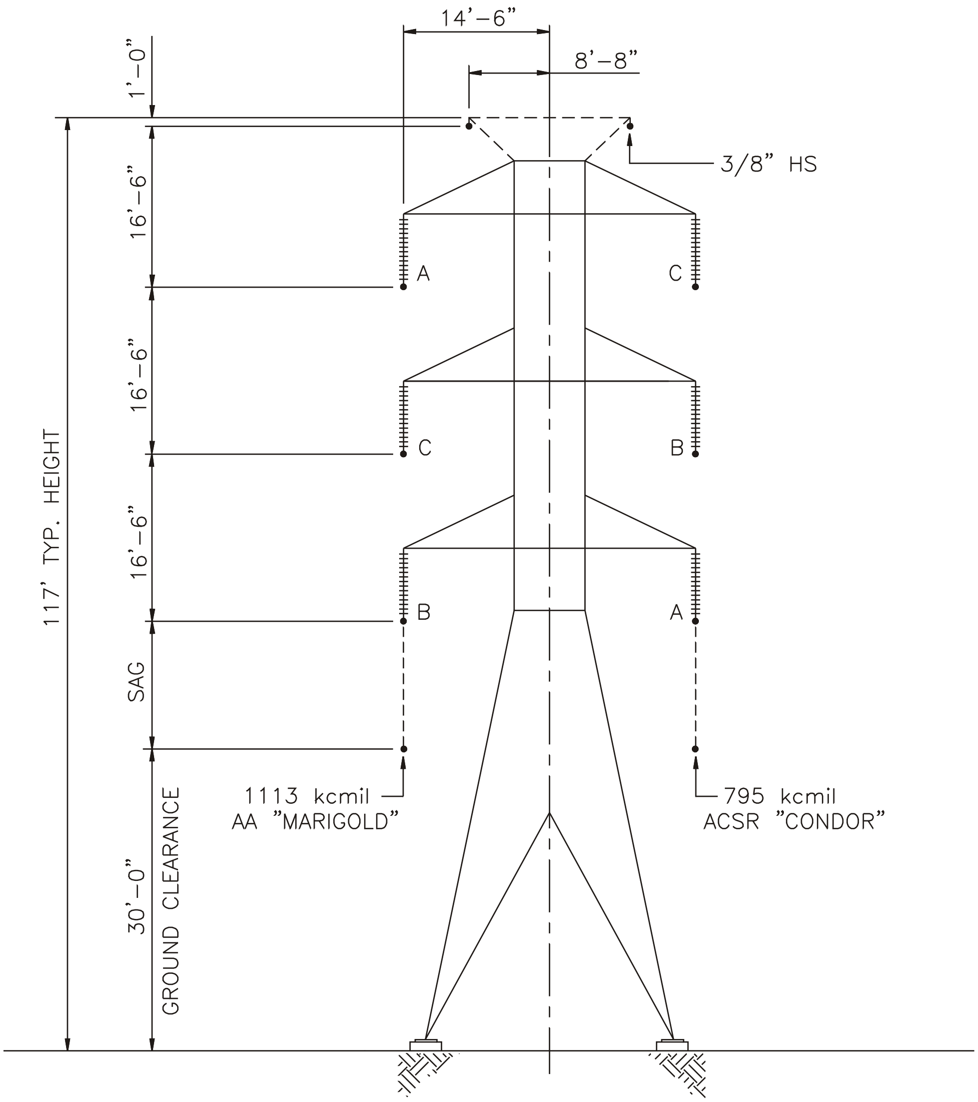
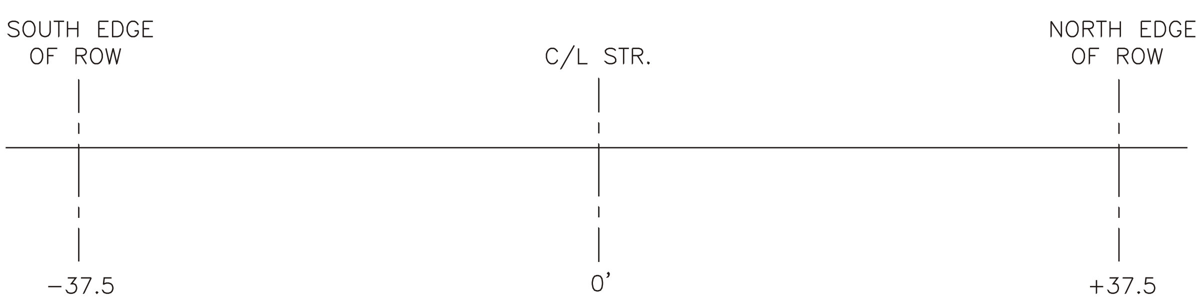
230 kV DOUBLE CIRCUIT LATTICE TOWER



STUDY ASSUMPTIONS FOR EMF CALCULATIONS
VIEW LOOKING WEST



NOT TO SCALE
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Cross Section B
230 kV Typical Double-Circuit Structure

Figure 5.5-3

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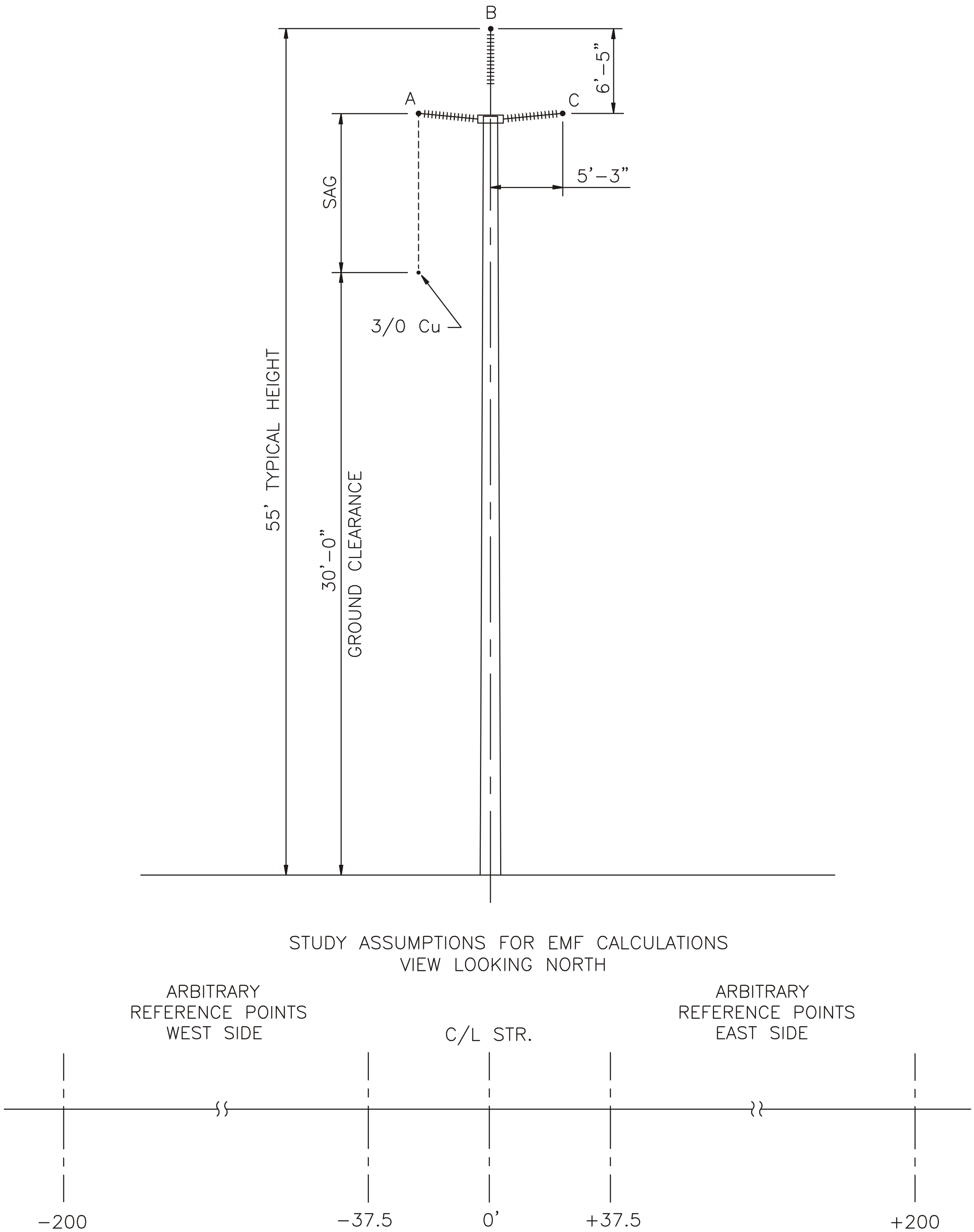
70 kV SINGLE CIRCUIT STRUCTURE



NOT TO SCALE

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Cross Section C
70 kV Typical Tri-Post Single-Circuit Structure

Figure 5.5-4

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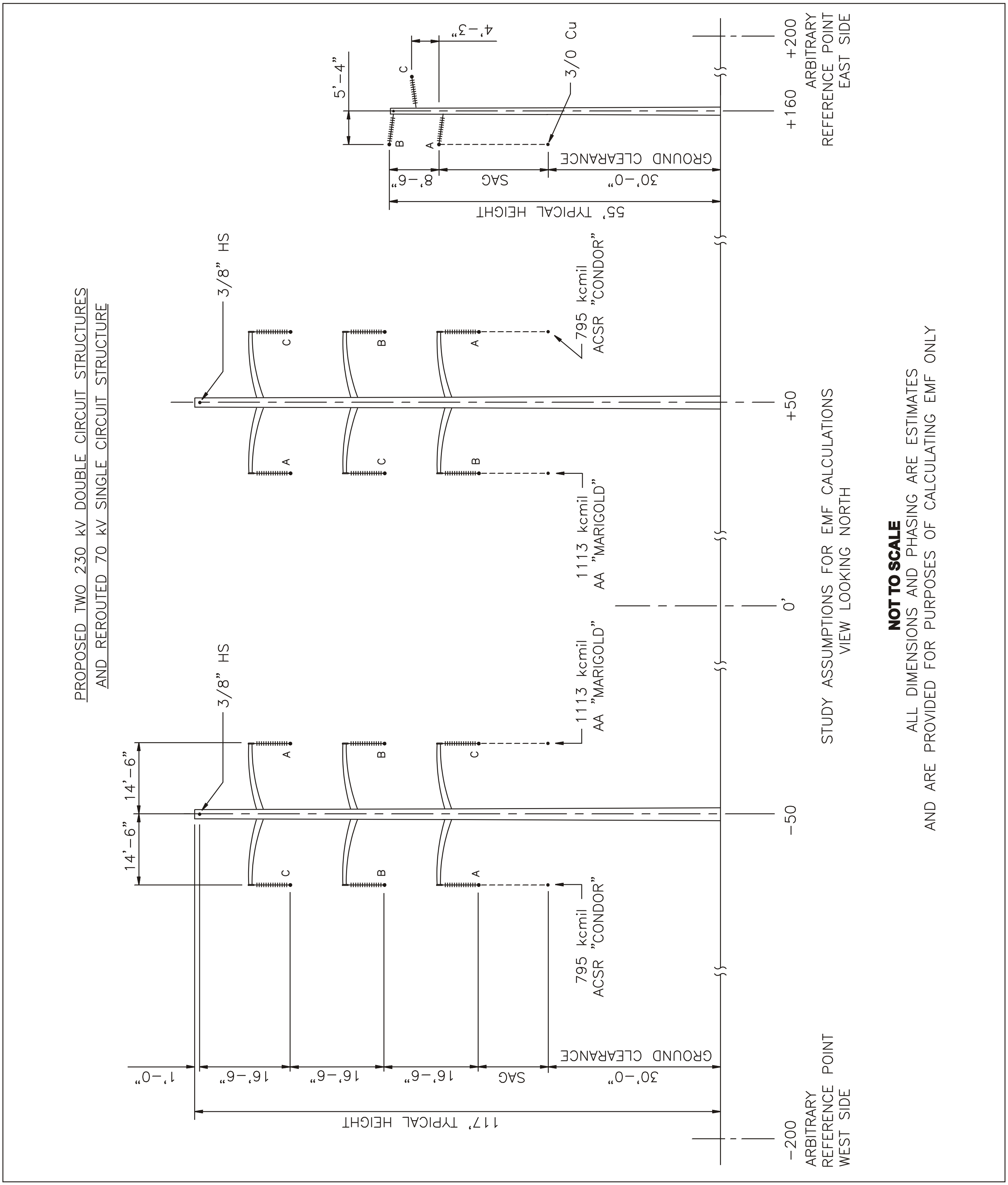

Cross Section D
Proposed CVEC Interconnection Corridor

Figure 5.5-5

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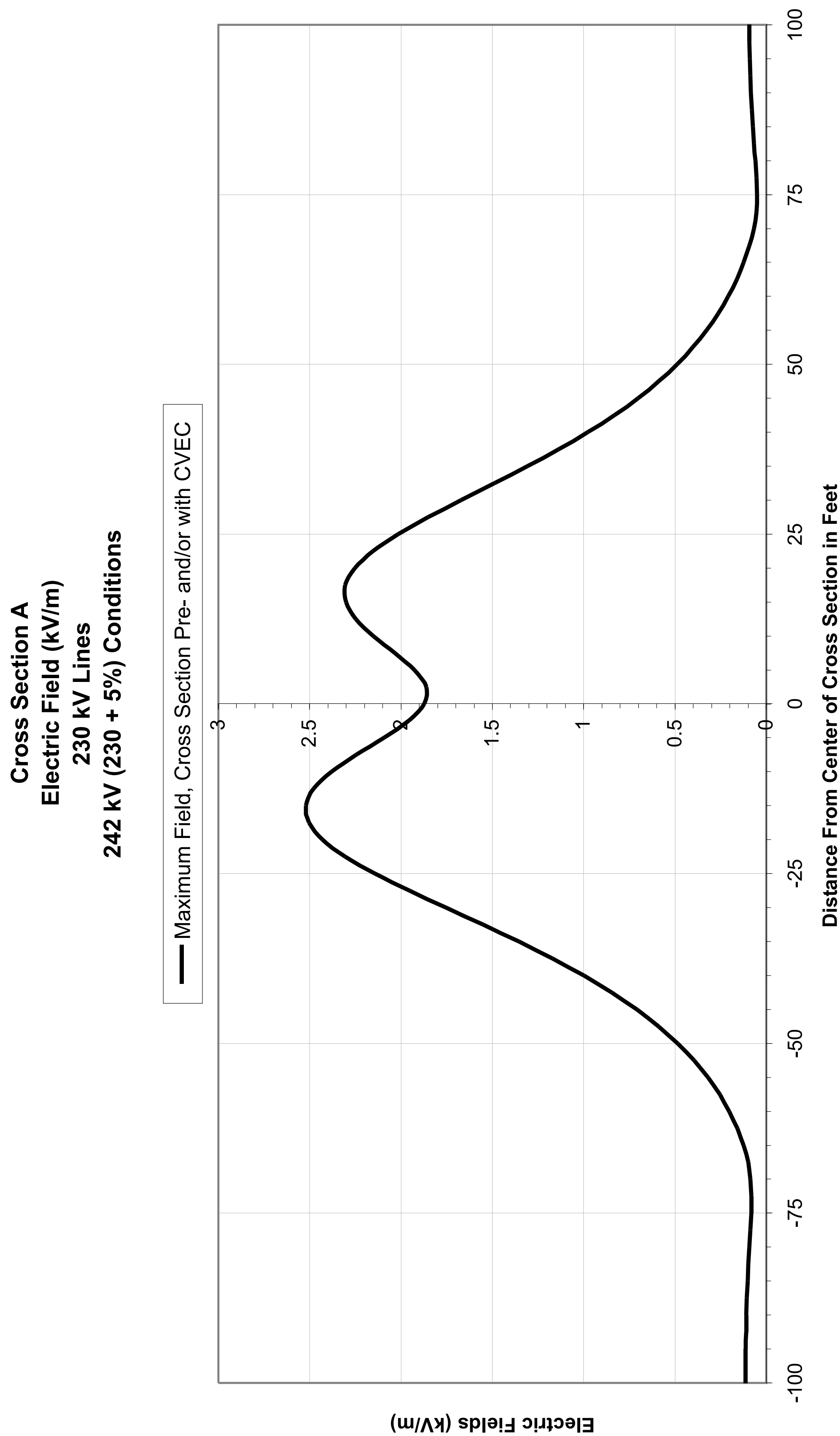

Cross Section A
Electric Field

Central Valley Energy Center -
Calpine Corporation

Figure 5.5-6

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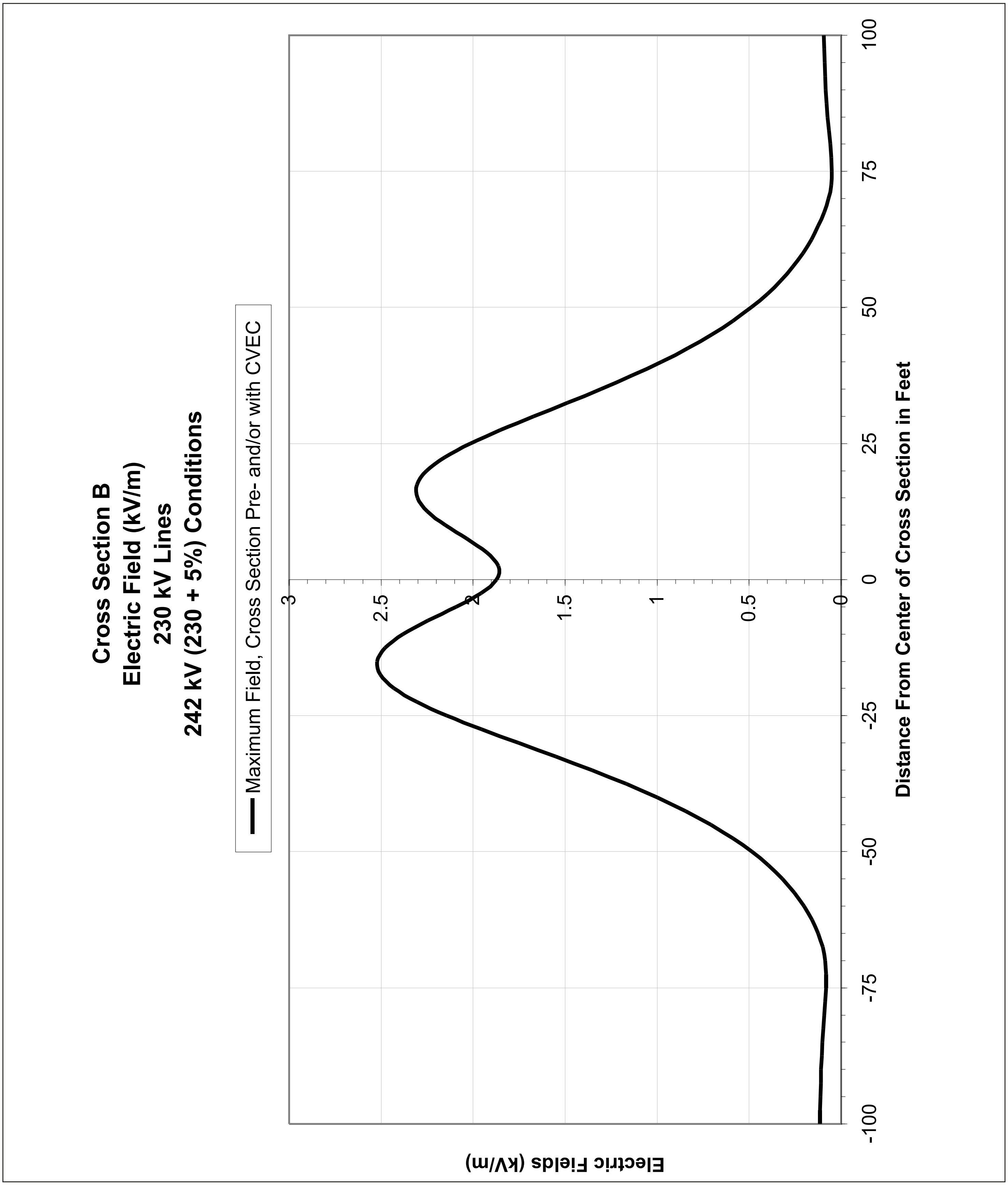

Cross Section B
Electric Field

Figure 5.5-7

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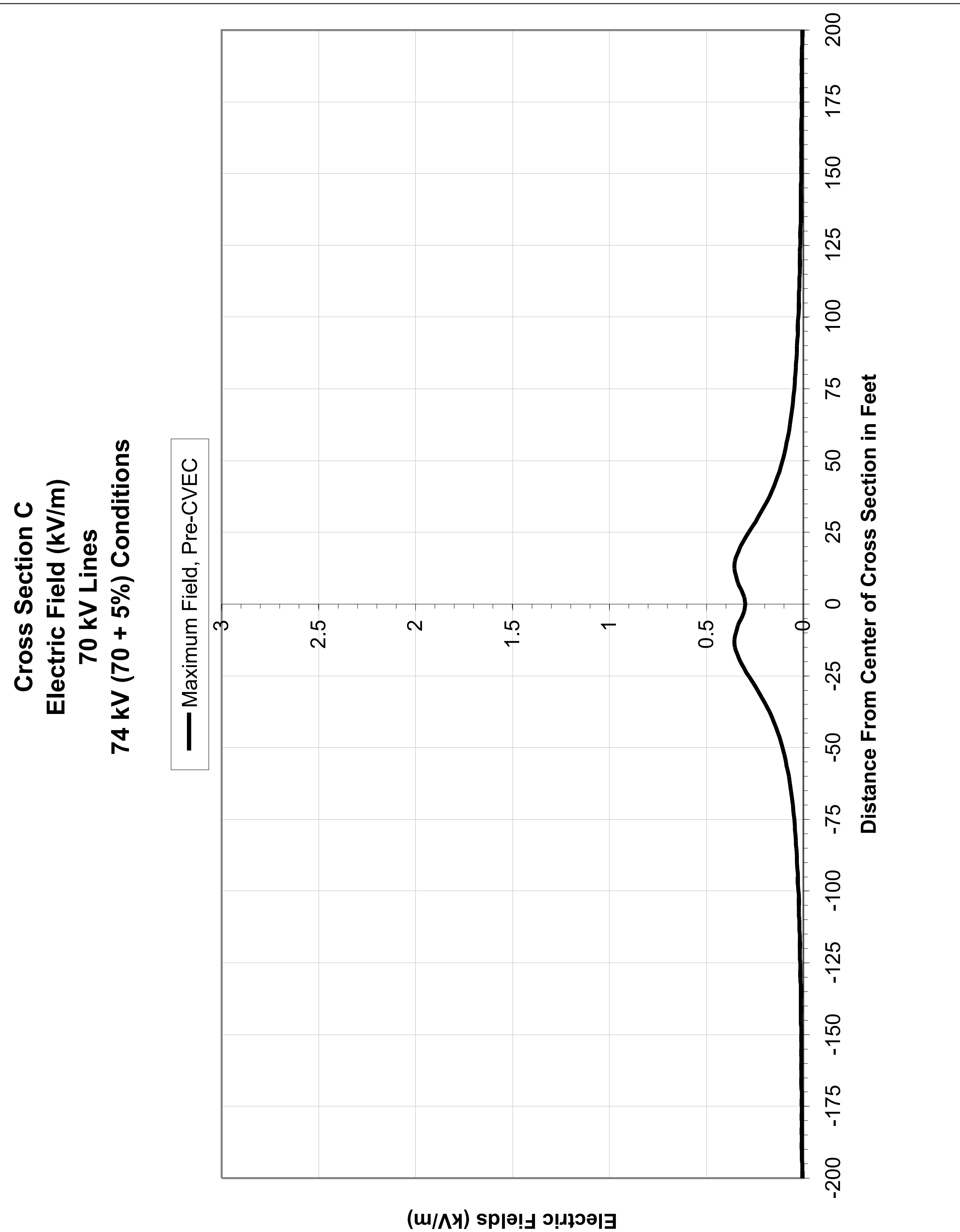

Cross Section C
Electric Field

Figure 5.5-8

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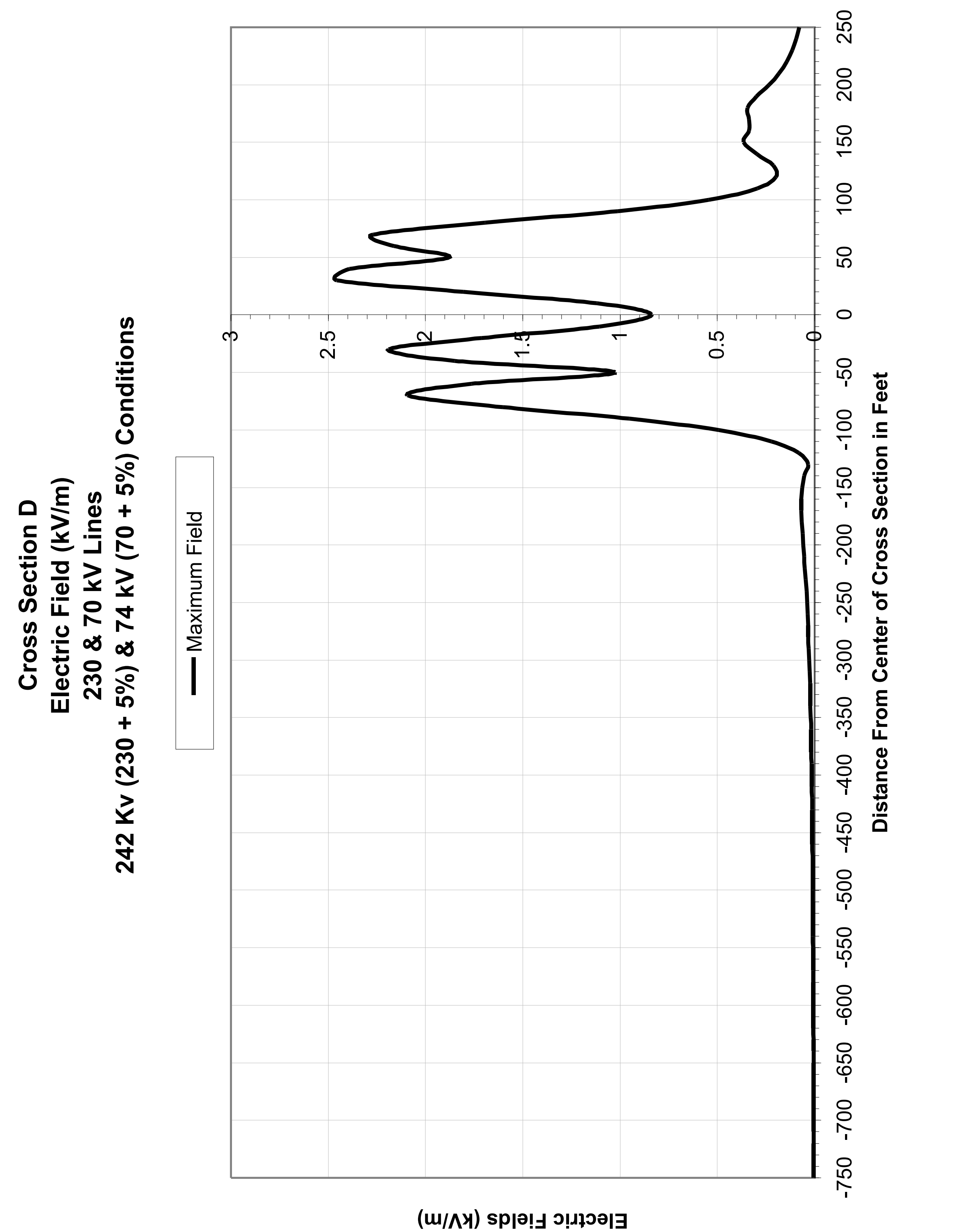

Cross Section D
Electric Field

Figure 5.5-9

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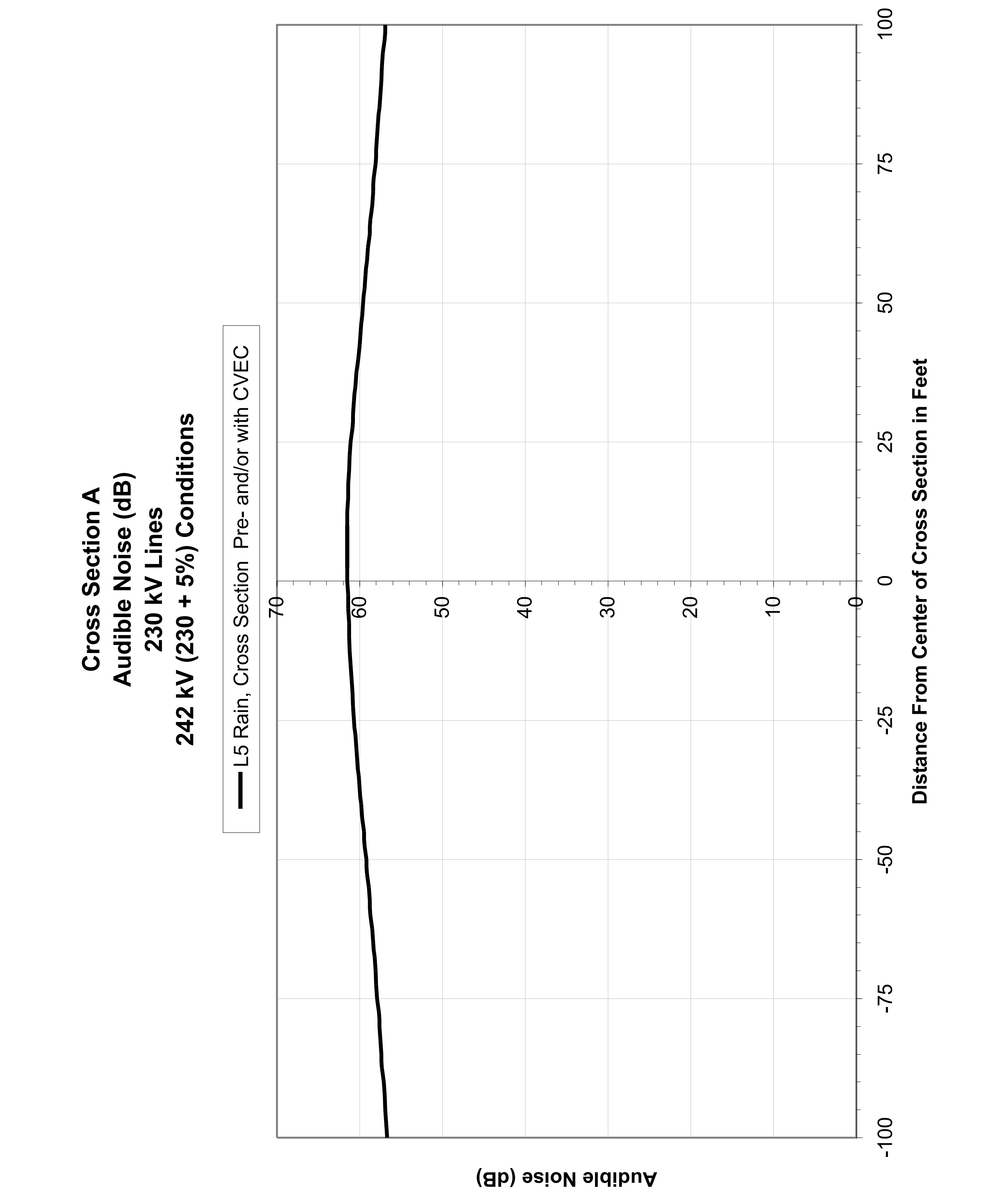

Cross Section A
Audible Noise

Central Valley Energy Center -
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Figure 5.5-10

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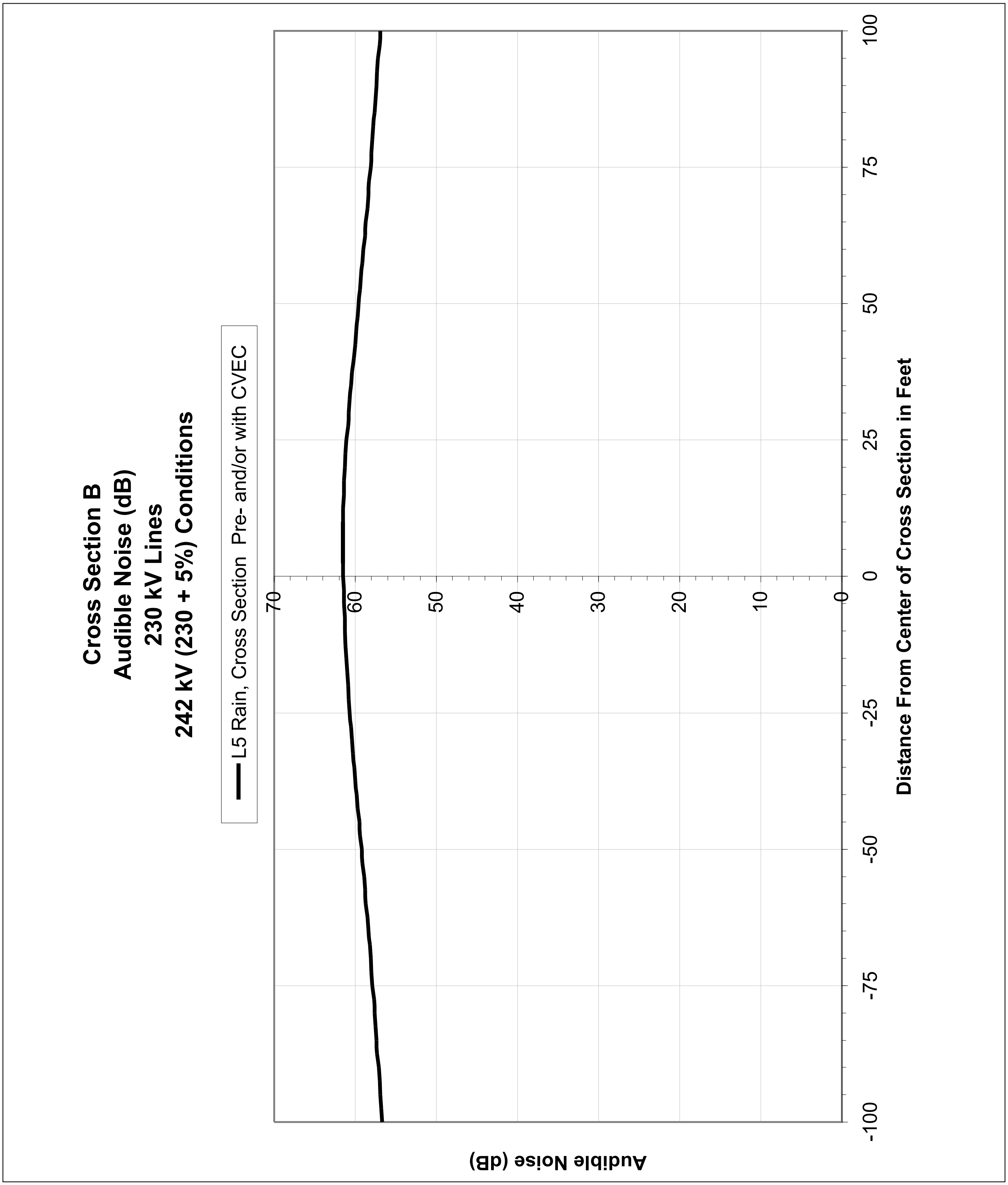

Cross Section B
Audible Noise

Figure 5.5-11

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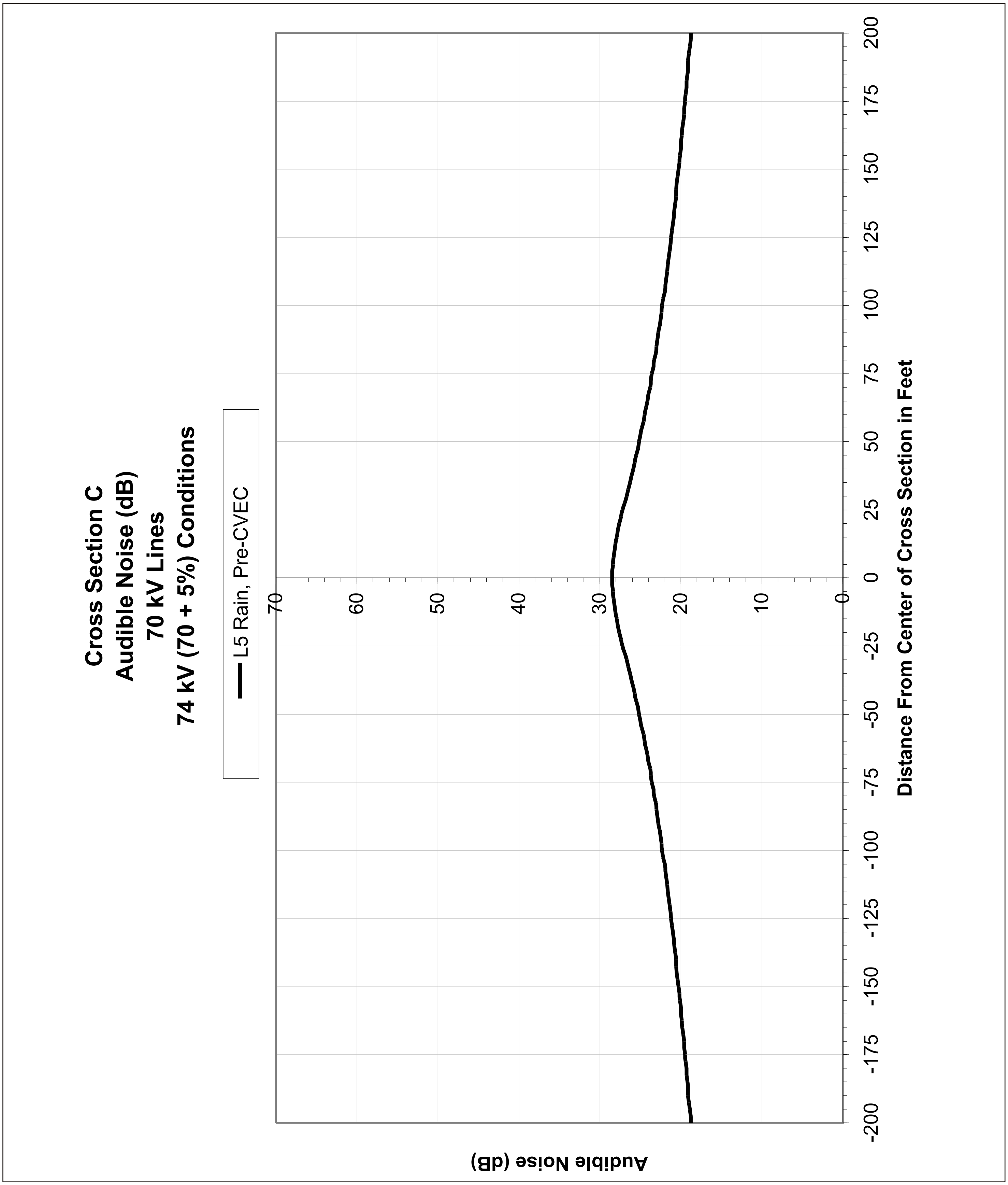

Cross Section C
Audible Noise

Figure 5.5-12

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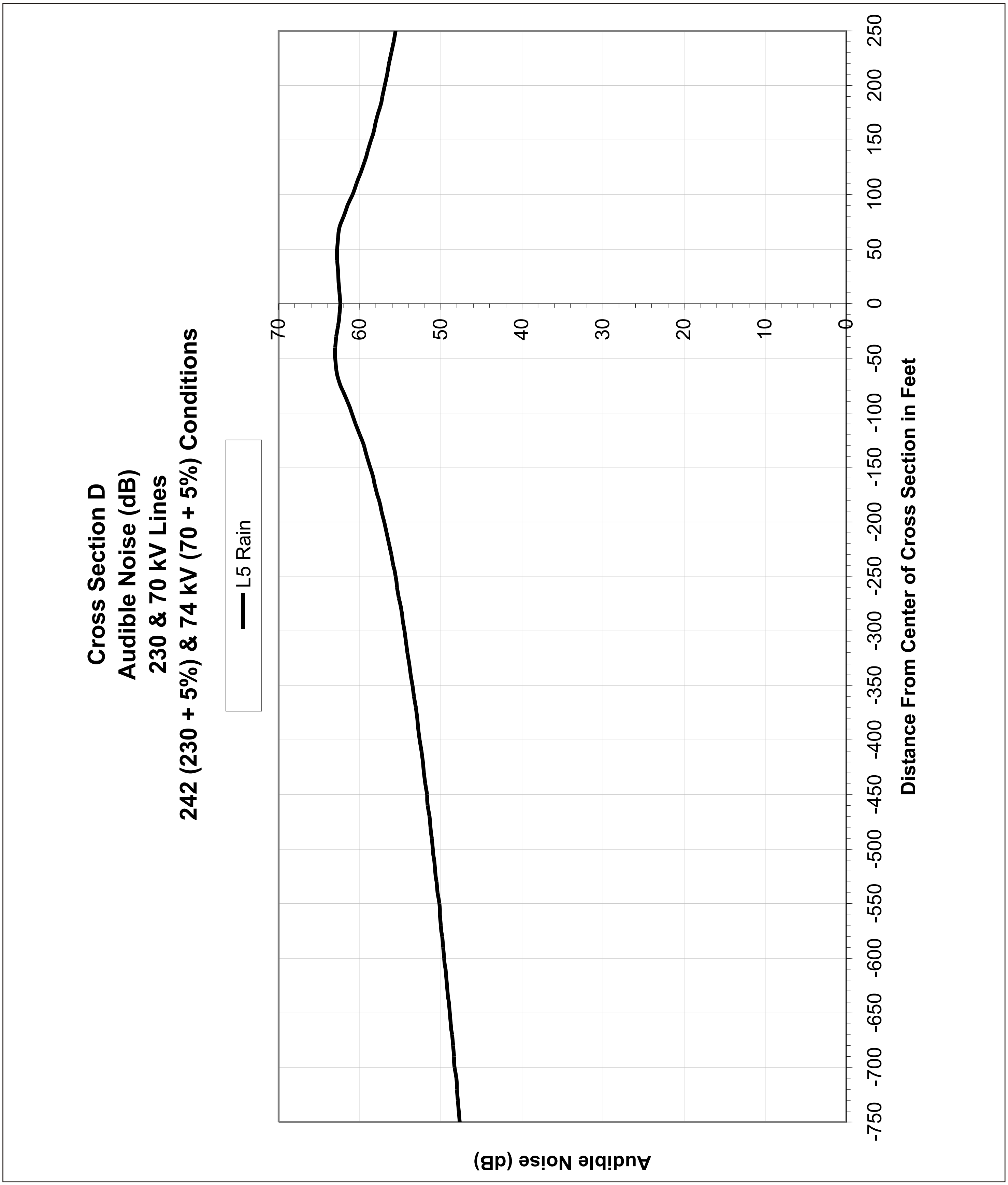

Cross Section D
Audible Noise

Figure 5.5-13

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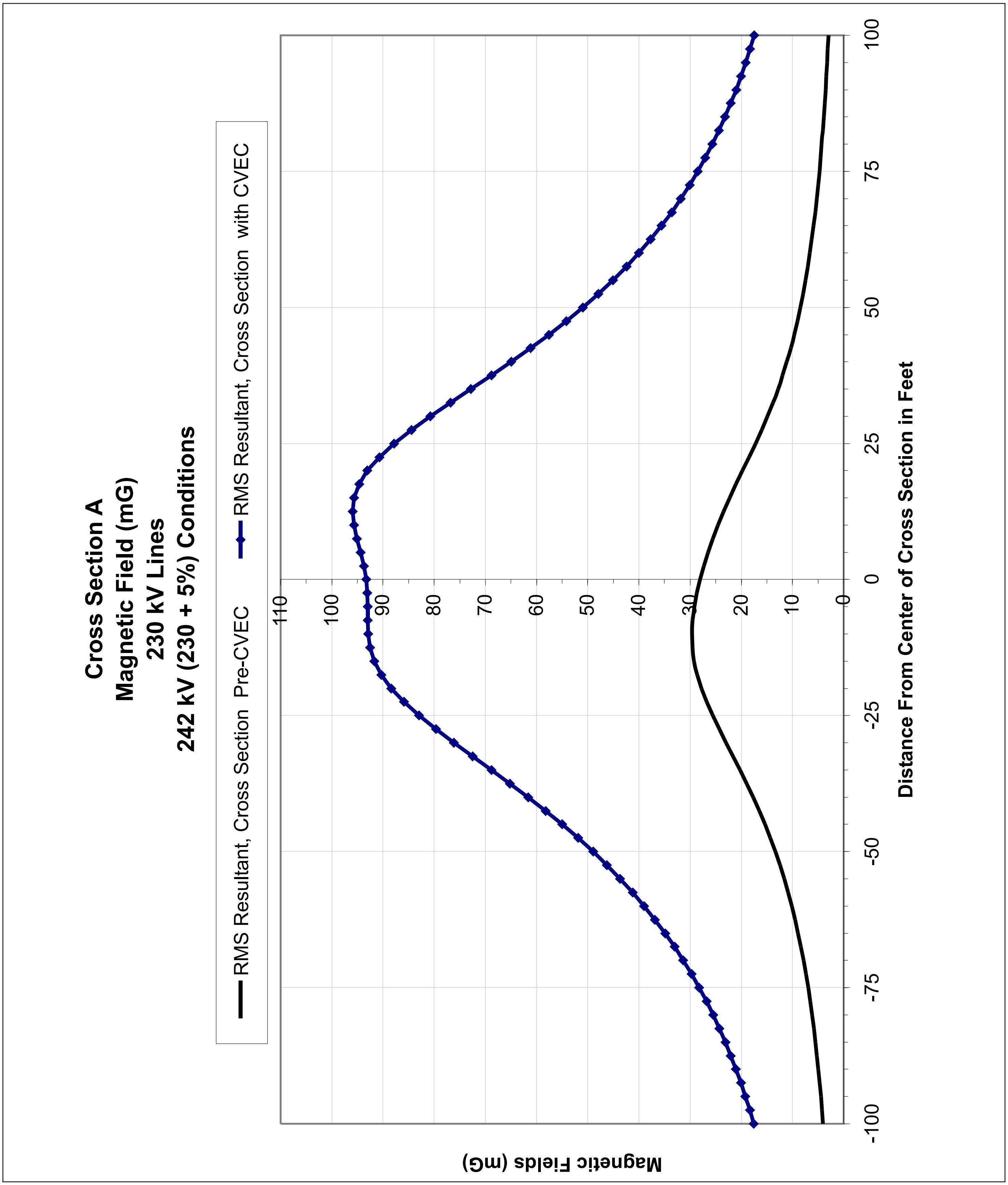

Cross Section A
Magnetic Field

Central Valley Energy Center -
Calpine Corporation

Figure 5.5-14

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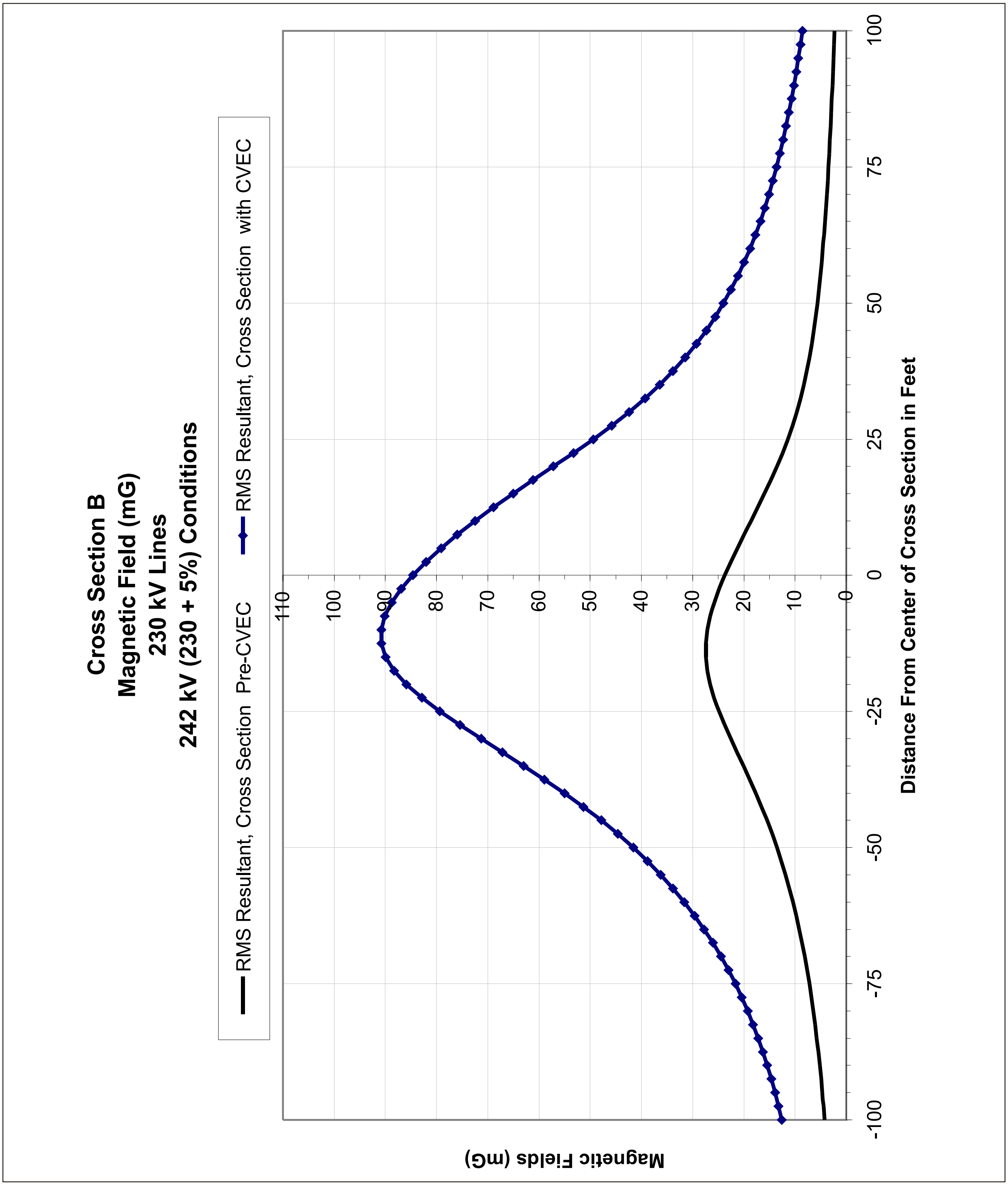

Cross Section B
Magnetic Field

Figure 5.5-15

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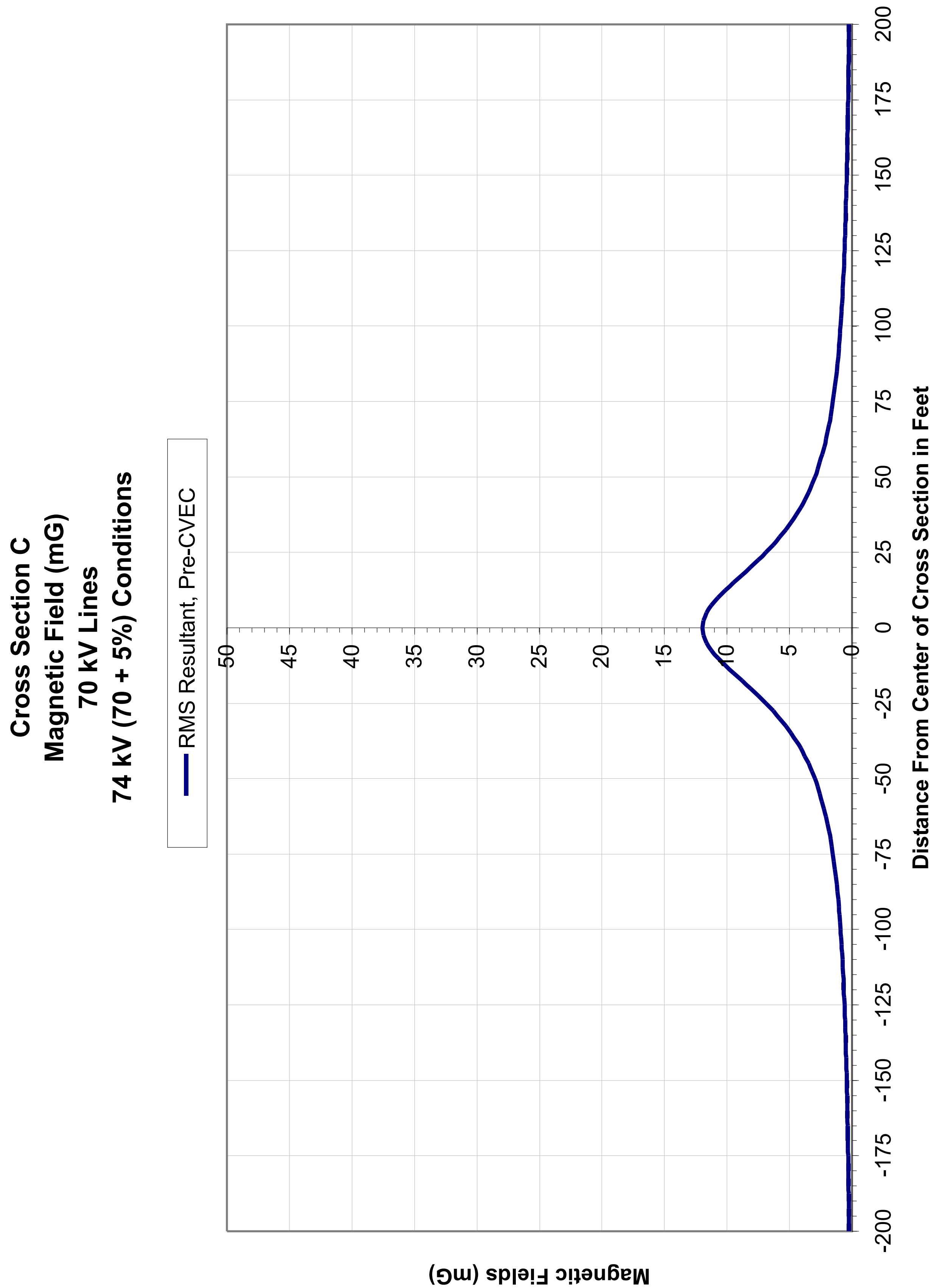

Cross Section C
Magnetic Field

Central Valley Energy Center -
Calpine Corporation

Figure 5.5-16

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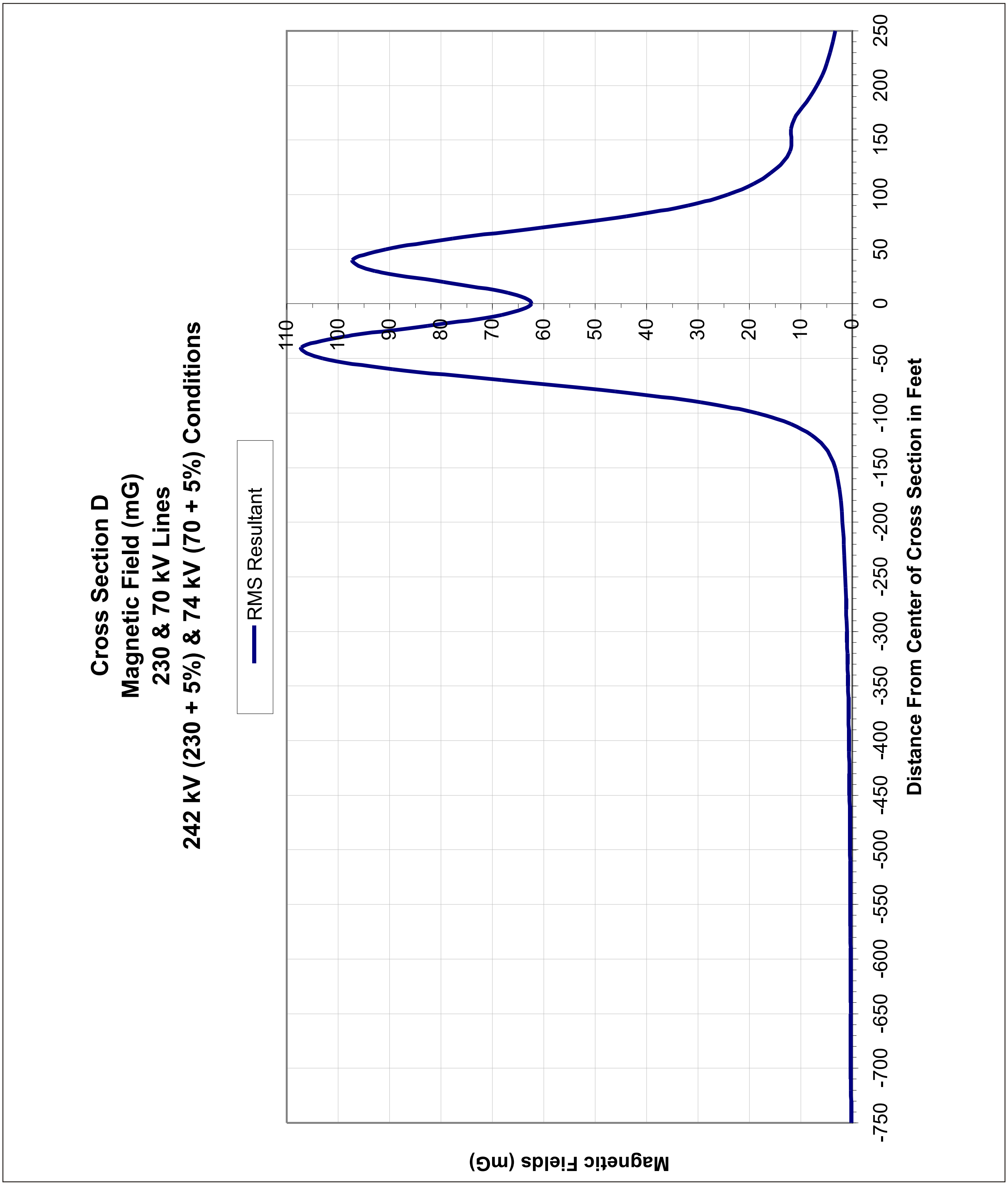

Cross Section D
Magnetic Field

Central Valley Energy Center -
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Figure 5.5-17

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